OCT 7 1924

NEERING," SEPTEMBER 26, 1924.

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ENGINEERING:

An Illustrated Weekly Journal.

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VOL. CXVIII.—No. 3065.] LONDON: FRIDAY, SEPTEMBER 26, 1924. [Registered at the General Post Office as a Newspaper.] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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Steam & Crude Oil Road Rollers, &c.
1869

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CULVER STREET WORKS, COLCHESTER.
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ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement page 36.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London."—Great Eastern Road, Stratford, E. 15. 1794

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RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1948

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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION of RAILWAY and TRAMWAY ROLLING STOCK.
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Specification and Workmanship equal to Main Line Locomotives.
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FOR IMMEDIATE DELIVERY.

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Estd. 1854. 2348

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DESIGNERS and BUILDERS
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For ALLUVIAL GOLD, PLATINUM & TIN, HARBOUR, RIVER & CANAL.—Gravel Dredgers, SCREENS.—DREDGE BUCKETS & Parts, all sizes.
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Wireless Receiving Sets.
FELLOWS BROS., LTD.,
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Fire-lighter Machine, Glovers' patent briquetting, perfect order, cost over £350. Will be sold cheap to prompt purchaser.—Apply, CONAN, 44, Kildare Street, Dublin. F 746

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Horizontal STEAM ENGINE by Marshall, Cyl. 13 in. dia. by 27 in. stroke.
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisements pages 35 and 38.

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ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES } ROW'S PATENTS.
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Special designs only.
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FOR SHEET AND PLATE WORKING.
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Diesel Engines, 300, 530, 800, 1200 and 1750 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. For all spares above sizes in stock.
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Overhead Electric Two-ton RUNWAY (New) FOR SALE, Herbert Morris, cage operated, packed as just delivered, 230 feet with one bend, approximate height 28 feet. With or without 3 phase Motors 220 volts. Magnificent plant. Will sell at 25 per cent. sacrifice.—Apply, C. L. STIFF & CO., LTD., Slag Breakers, East Ardsley, near Wakefield. F 672

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Refrigerating and Ice-making Machinery.
Feed Water Heaters.
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Auxiliary Surface Condensers,
&c., &c. 2337

YARROW & CO. (1922), LTD., GLASGOW.
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MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 26, Sept. 19. 2402

Matthew Paul & Co., Ltd.
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See Full Page Advt., page 60, Sept. 12.

Taylor & Challen
Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 52, Sept. 12. 8196

For Sale, Motor-Driven Air COMPRESSOR, by Belliss & Morcom. 1000 cubic ft. per min. 100 lbs. pressure, with 500 volt D.C. motor.—THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. D 291

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Switches and
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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

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SESSION 1924-25.

Vice-Chancellor: SIR HENRY HADOW, C.B.E., D.Mus., LL.D.

DEPARTMENTS OF MECHANICAL, ELECTRICAL, AND CIVIL ENGINEERING, METALLURGY, MINING, FUEL TECHNOLOGY, AND GLASS TECHNOLOGY.

The Courses in the above Departments extend over three or four years and prepare students to become specialists in one or other of these branches of Applied Science.

The LECTURE COURSES in all the Departments are supplemented by Practical Training in Laboratories and Workshops, which are fully equipped for the purpose of advanced scientific teaching, investigation and research.

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The LECTURE COURSES commence OCTOBER 1st, 1924.

The TECHNICAL LABORATORY COURSES commence SEPTEMBER 23rd, 1924.

For further details of the Courses and for particulars of the Degrees, Associateships, Diplomas, and Certificates awarded on their successful completion, application should be made to

W. M. GIBBONS, Registrar. F 664

ENGINEERING AND TECHNICAL OPTICS.

Northampton Polytechnic INSTITUTE.

ST. JOHN'S STREET, LONDON, E.C.1.

ENGINEERING DAY COLLEGE.

Full-time Day Courses in the Theory and Practice of Civil, Mechanical and Electrical Engineering. The Courses in Civil and Mechanical Engineering include specialisation in Automobile and AERONAUTICAL Engineering, and those in Electrical Engineering include specialisation in RADIO-TELEGRAPHY.

The ENTRANCH EXAMINATION will be held on Tuesday and Wednesday, 23rd and 24th September. The Courses include periods spent in commercial workshops and extend over four years. They also prepare for the Degree of B.Sc. in Engineering at the University of London. Fees £18 and £13 per annum.

THREE ENTRANCH SCHOLARSHIPS of £62 each for the complete course, will be offered for competition at the Entrance examination.

OPTICAL ENGINEERING AND TECHNICAL OPTICS.

Full and Part-time Courses in this important department of Applied Science are given in specially equipped laboratories and lecture rooms. The annual entrance examination is held in September.

All day courses commence on Monday, 29th September.

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in all branches of Mechanical and Electrical Engineering commence on Monday, September 22nd, 1924.

The Laboratories both Mechanical and Electrical, are well equipped with modern apparatus which, on the Mechanical side, provides for specialisation in Automobile and Aeronautical Engineering and, on the Electrical side for specialisation in Alternate and Continuous Current Work, in Radio-Telegraphy and Telephony, and in Electrical Testing.

More complete particulars, together with conditions of entrance, etc., and all information respecting the work of the Institute can be obtained at the Institute or on application to

S. C. LAWS, M.A., M.Sc., Principal. F 728

Engineering Tuition:—B.Sc.

(First Hons. Eng.) assisted by M.Inst.C.E. and staff gives Expert and Individual Tuition for all exams., including Inst.C.E., Inst.M. & Co.E., Inst.Mech.E., and Lond. Univ. Degree (Matric, Inter. and Final). Correspondence Courses or personal tuition in drawing office.—Apply, H. G. LONGBOTTOM, B.Sc., 3, 5 and 7, Old Queen Street, Westminster, S.W.1. Tel: Vic. 761. F 705

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

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and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2382

Engineering Drawing.—

Special Postal Course in Engineering Drawing. Enrol now. Fee Three Guineas for the complete course. Also day tuition in Office by qualified teacher.—PERCY PITMAN, M.I.Mech.E., (nephew of the late Sir Isaac Pitman), 23, Victoria Street, London, S.W.1. 2297

TENDERS.

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 3rd October, 1924,

Tenders for the Supply of:—

1. KHAKI JOINTING PASTE.
2. RAILWAY TICKETS.
3. SPRING STEEL.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG, Secretary.

Offices: The White Mansion, 91, Petty France, Westminster, S.W. 1.
18th September, 1924. F 931

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for:—

(A) Two GOODS ENGINES and TENDERS 2 ft. 6 in. gauge.
(B) 6,000 STEEL BOILER TUBES.
(C) 18 COPPER FIREBOX TUBE PLATES.

Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 19th September, 1924.

A fee of 20s. will be charged for each Specification, which is NOT returnable.

Tenders must be submitted not later than NOON on Thursday, 2nd October, 1924,

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the orders.

By Order of the Board, R. C. VOLKERS, Secretary. F 929

ADMINISTRATIVE COUNTY OF LONDON.

VICTORIA EMBANKMENT SUBWAY.

The London County Council invites

Tenders for the Construction

of TWO STAIRWAYS to the Existing Subway under the Victoria Embankment, near Westminster Bridge.

Persons desiring to submit tenders may obtain the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W.1, upon payment of £3 which will be returnable only if the Tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the Drawings, Specification and other contract documents may be inspected before the payment of the fee.

No Tender received after Four p.m. on Monday, 13th October, 1924, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, Clerk to the London County Council. F 948

THE ROYAL BOROUGH OF KENSINGTON.

TENDERS FOR WEIGHBRIDGE.

The COUNCIL of the above Borough are prepared to receive

Tenders for the Construction

of a NEW WEIGHBRIDGE of twenty tons capacity, at their Pembroke Road Depot, Warwick Road, Kensington.

Parties wishing to Tender can obtain information from the Borough Engineer's Department at the Town Hall, Kensington, W.8, as to the position proposed for the weighbridge, and they must furnish detailed Drawings and Specifications of the Machine to be supplied, and the price must include the construction of the necessary pit, all builder's work, and the delivery and fixing of the machine complete.

Tenders, sealed and endorsed "Tender for Weighbridge," must be delivered at the Office of the undersigned not later than Four o'clock in the afternoon of WEDNESDAY, the 15th October, 1924.

The Council do not bind themselves to accept the lowest or any Tender.

The Contractor will be required to enter into a written contract and, if required by the Council, to provide two good and sufficient surities for the due performance thereof.

The Contract Deed will be prepared at the expense of the Council.

By Order, HORACE RAPSON, Town Clerk.

Town Hall, Kensington, W.8.
17th September, 1924. F 937

BISHOP'S STORTFORD URBAN DISTRICT COUNCIL.

TENDERS FOR PUMPING MACHINERY.

The above Council invite

Tenders for the Supply and

ERECTION at the Sewage Pumping Station, Great Hallingbury, Bishop's Stortford, of a TANGYE HORIZONTAL DUPLEX DOUBLE-ACTING PUMP, to be driven by an Oil Engine of not less than 66 B.HP., made by one of the following makers, namely:—

Messrs. Tangyes Limited,
Messrs. Ruston & Hornsby Limited,
Messrs. Crossley Brothers Limited.

Specification and Form of Tender can be obtained on and after the 29th September from the Engineer and Surveyor of the Council (ROBERT S. SCOTT, A.M.I.C.E.), Council Offices, Bishop's Stortford, and application for such Specification and Form of Tender must be accompanied by a cheque for Two Guineas, which sum will be returned after the receipt of a *bona fide* Tender.

Sealed Tenders, marked "Tender for Machinery," must be delivered to the undersigned not later than Monday, the 20th day of October, 1924.

The Council do not bind themselves to accept the lowest or any Tender.

C. J. HANCOX, Clerk of the Council.

Council Offices, Bishop's Stortford.
24th September, 1924. F 934

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

OVERHEAD ELECTRIC TRAVELLING CRANES.

Tenders due on the 16th October, 1924.
Tender Forms obtainable from above. F 960

CITY OF LEICESTER.

STORM WATER AND SEWAGE DISPOSAL WORKS.
Contract No. 11.

STEEL SHEET PILING.

The Leicester Corporation are prepared to receive

Tenders for the Supply,

DELIVERY and DRIVING complete, of about 1,100 tons of STEEL SHEET PILING, and all other works in connection therewith, according to the drawings prepared by the City Surveyor.

Plans may be seen and copies of the Conditions of Contract, Specification, Bill of Quantities, with Form of Tender, etc., obtained at my Office on and after September 22nd, 1924, on payment of the sum of £2, which will be returned on receipt of a *bona fide* Tender.

Cheques, &c., to be crossed and made payable to the Leicester Corporation.

Sealed Tenders, together with the Summary of Tender on the Forms supplied, filled up and addressed to "The Chairman of the Sewage Works and Farms Committee, Town Hall, Leicester," are to be delivered not later than Nine a.m. on October 13th, 1924, endorsed "Tender for Steel Sheet Piling."

The Corporation do not bind themselves to accept the lowest or any Tender.

E. GEORGE MAWBEY, M.Inst.C.E., City Engineer and Surveyor.

Town Hall, Leicester.
September, 1924. F 892

STATE ELECTRICITY COMMISSION OF VICTORIA, Melbourne, Victoria, AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Yallourn Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT GENERAL FOR VICTORIA, Melbourne Place, Strand, London, W.C.2.

SPECIFICATION No. 24/90—
22,000 VOLT CABLE AND ACCESSORIES.

CHARGE:—£1 for the first three copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £100 is to be lodged with Tender.

The Specifications may be inspected at the above mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 24th November, 1924.

R. LIDDELOW, Secretary. F 803

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

1. Metals.
2. Sheffield Tools, etc.
3. Copper Tubes, Brass Sheets, etc.
4. Yorkshire Iron.
5. Locomotive Boilers.
6. Points and Crossings, etc.
7. Mild Steel Bars, Sections, etc.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Metals," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 10th October, 1924, for Specifications Nos. 1, 2, 3, and 4, the 24th October 1924, for Specifications Nos. 5 and 6, and 21st November, 1924, for Specification No. 7.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge which will not be returned, will be made of 5s. for each copy of Specifications Nos. 1, 2 and 3, and of 10s. for each copy of Specifications Nos. 4, 5, 6 and 7.

Copies of the Drawings may be obtained at the Offices of the Consulting Engineers to the Company, Messrs. ROBERT, WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD, Managing Director.

91, Petty France, S.W.1 F 938

LONDON AND NORTH EASTERN RAILWAY.

The Directors are prepared to receive

Tenders for Steelwork,

IRONWORK, etc., including ERECTION, required for two sets of fixed Gravity Spouts and Hoppers, Telescopic Hanging Spouts, and all necessary equipment, also Crane Foundation for the New North Side Staiths at Blythe. The total weight of steel and ironwork is approximately 91 tons.

Plans may be seen and Specifications, Detailed Quantities, and Form of Tender obtained on personal application only at the Branch Office of Mr. C. F. BENGOUGH, the Company's Chief Engineer for the North Eastern Area, Forth Banks, Newcastle-on-Tyne, on and after October 1st.

Sealed Tenders, marked "Tender for Steelwork for New North Side Staiths, Blythe," must be sent to the Joint Secretaries, L. & N.E. Rly., Marylebone Station, London, N.W.1, not later than Nine a.m. on Wednesday, October 15th.

The Directors do not bind themselves to accept the lowest or any Tender.

JAMES McLAREN, G. F. THURSTON, Joint Secretaries.

Secretary's Office, Marylebone Station, N.W.1.
15th September, 1924. F 926

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 10th October,

Tenders for the Supply of:—

1. AXLES for Carriages and Wagons.
2. WHEELS and AXLES for Wagons.
3. STEEL SLEEPERS and Accessories.

Tenders must be made on forms, copies of which with Specification, can be obtained at these Offices on payment of 20/- each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG, Secretary.

Offices: 91, Petty France, Westminster, S.W.1.
24th September, 1924. F 971

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, COPTHALL AVENUE, LONDON, E.C.2, invite

Tenders for:—

1.	Fencing Wire Strand	Per 2/6
2.	Spare Parts of Carriages and Wagons (brake beams, centre pins and spring washers)	,, 1/6
3.	Steel Tyres for Loco. Engines & Tenders	,, 10/-
4.	Wheels & Axles, etc., for Loco. Engines and Tenders	,, 10/-
5.	India Rubber Hose Pipes, Sheets, etc.	,, 5/-
6.	Locomotive Boilers, H.S.2 and D.S.2 Types	,, 20/-
7.	Brass and Iron or Steel Screws	,, 7/6
8.	Drawn or Extruded Brass Strips, Angles, etc.	,, 2/6
9.	Spring Steel	,, 10/-
10.	Fencing Materials	,, 5/-
11.	Firebricks	,, 5/-
12.	Laminated Springs	,, 10/-
13.	Tyre Retaining Rings	,, 5/-
14.	Bolts, Nuts, Rivets, etc.	,, 5/-
15.	Steel Drawbars, etc., for Wagons	,, 20/-
16.	Spare Parts of Carriages and Wagons (Cylindrical Buffers)	,, 7/6
17.	Plate Glass, etc.	,, 5/-
18.	Galvanized Sheets	,, 5/-
19.	Bright Brass Bars (For use in Automatic Lathes)	,, 2/6

Tenders are due by 11 a.m. on 7th October, 1924. Tender Forms obtainable at above address. Fees not returnable. F 972

THE SOUTH INDIAN RAILWAY COMPANY LIMITED, are prepared to receive

Tenders for the Supply of:—

(1) HINGES, etc.
(2) STEEL CRANKED FISHPLATES,
(3) FISHBOLTS and SPIKES.
(4) BOLTS, NUTS, RIVETS, etc.
(5) STEELWORK for Bridges.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Hinges," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 10th October, 1924, for Specifications Nos. 1, 2, 3, and 4, and on Friday, the 17th October, 1924, for Specification No. 5.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 2/6 for each copy of Specifications Nos. 1, 2, and 3, of 5/- for each copy of Specification No. 4, and of £1 0s. 0d for each copy of Specification No. 5.

Copies of the Drawings may be obtained at the Offices of the Consulting Engineers to the Company, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD. Managing Director.

91, Petty France, S.W.1.
24th September, 1924. F 977

PORT OF BRISTOL.

RECONSTRUCTION of SWING BRIDGE, JUNCTION LOCK, CUMBERLAND BASIN, BRISTOL.

The Docks Committee invite

Tenders for the Reconstruction

of the SWING BRIDGE over the Junction Lock, Cumberland Basin, Bristol. The work in the contract is to include foundations, abutments, steelwork, and opening and closing machinery. Building Contractors will be allowed to sublet the steelwork and the machinery. Bridge Construction Contractors will be allowed to sublet the building work and the machinery. Tenders must, however, include for the whole of the work.

On and after Monday the 29th day of September, 1924, copies of the Specification etc., can be obtained from the undersigned on production of a receipt to the undersigned showing that a deposit of £5 has been paid to the *Bristol Docks Committee, to whom all cheques must be sent and made payable.* The deposit will be returned to *bona fide* tenderers after the receipt of the tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope endorsed "Tender for Reconstruction of Swing Bridge, Cumberland Basin, Bristol," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before Ten a.m. on Monday the 27th day of October, 1924.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE, Chief Engineer.

Chief Engineer's Office, Avonmouth Dock, Bristol.
24th September, 1924. F 978

APPOINTMENTS OPEN.

The Stanton Ironworks

COMPANY LIMITED, near Nottingham, REQUIRE the SERVICES of an Experienced METALLURGIST used to Cupola and Gas Producer practice.—Apply, in writing, giving full particulars and present salary to the above, addressed "Foundry General Manager." F 980

DREDGING AND LAND RECLAMATION.

By ERNEST LATHAM, M.Inst.C.E.

DREDGING combined with land reclamation has presented a problem of interest to the civil engineer for many years past. To-day the design of dredgers and pumping plant has reached a high standard, and, given suitable plant, time, and money, dredging such materials as clay or alluvium is in itself not a difficult undertaking. Efficient dredgers of the bucket (side and centre ladder) type—self-propelling hopper dredgers—suction drag-head dredgers and sea-going hoppers are on the market to-day, and engineers can take their choice of design and specification to suit their particular requirements. All this is thanks to the genius of the mechanical engineer.

Generally, the most important factor to be considered in drawing any dredging *cum* reclamation specification is economy, especially as applied to the deposit of sludge after it has been brought to the surface, *i.e.*, whether it is cheaper to take it to sea or to dump it ashore. In most cases the cost of getting the material ashore is about the same as that of bringing it to the surface, so that economy demands a practical site for reclamation as well as a mere site for tipping spoil. This consideration must never be overlooked. For instance, in any commercial harbour, it is fairly obvious that any reclaimed area on the harbour site must be capable of affording rail and road access as well as presenting the possibility of quay development along the water frontage. It is just such a problem as this which at the moment is exercising the engineers of at least one harbour of first importance in the British Isles. We have, however, on the civil engineering side of the question, a lot of leeway to make up, as it still appears impossible for us to establish any basis of contract which has even the remote possibility of presenting an equitable aspect either to principal or contractor.

It is clear that it is not fair to expect the dredging contractor to accept payment for his work purely on the quantity or tonnage of the solid which he is able to dredge. In some cases on an awkward "cut" he may at first get little more than silt, as in the case of dredging existing shipping berths, whilst on the other hand, he may reap a harvest on cutting a new channel to a fairway. It is equally unfair to the principal to pay a contractor for a hopper full of dredged sea water at the same rate that he pays for an equal quantity of dredged sludge. For this reason and, for each case, some fair scale of payment should be worked out, and the author considers that a scale of pay based on the quantity of solid in proportion to the quantity of water raised is the only equitable scale of payment. This seems, at first sight, a simple matter to arrange, but, in practice, it is far from being the case. The reason is that no dredging contractor, in his senses, would work to a specification where payment was offered in direct proportion to solid cubic contents raised and, therefore, a compromise is required.

It is then of some use to examine first the purely physical aspect of this important question. The fractional volume (in cubic feet) of solid per cubic foot of sludge can be determined from the following formula :—

$$x\,D + (1 - x)\,63 = d \quad . \quad . \quad . \quad (1)$$

Where—

x = fractional volume in cubic ft. of solid in each cubit foot of dredged sludge.
D = density of dried-out solid in lbs. per cub. ft.

Consequently, x D is the weight of solid dredged in each cubic foot of sludge and $(1 - x)$ 63 is the weight of water dredged in one cubic foot of sludge. For convenience, the weight of estuarial water has been assumed as being 63 lb. per cubic foot and the term "D" must, of course, be settled as to value between the contracting parties, *e.g.*, the conditions as to time and temperature to be observed in the drying out process of selected samples. It further follows that if "V" is the displacement in cubic feet of any hopper due to its load, and "v" is the volume in cubic feet of the hopper fill (*i.e.*, the volume of the sludge), then the term $\frac{V \times 63}{v}$ gives at once the density of sludge in lbs. per cubic foot represented by the term "d" in equation (1).

If the condition of the dredged solid material (as subsequently dried) remains more or less constant, which is usually the case in harbour work, some interesting deductions follow. These are best evidenced by citing a specific case upon which the author's firm was recently asked to advise. The dredged material, in the case in question, when dried out under specified conditions, was reported to give a density of 163 lb. per cubic foot. If the assumption of regarding a hopper simply as a "density bottle" problem were correct, the results given in the table below would undoubtedly apply.

Fractional Volume "x" of Solid per cubic foot.	Percentage of Solid (by Volume)	Density of Sludge in lbs. per cub. ft.
	Per cent.	
1/10	10	73
1/5	20	83
3/10	30	93
2/5	40	103
1/2	50	113

We have here clearly the genesis of an idea on which to frame a scale of payment to a dredging contractor which, subject to a sliding scale of rates, could be applied either to dredging and dumping at sea or depositing material on given areas ashore. It is noticeable from the above figures that a reduction of about 11 per cent. in the density of the sludge means a loss of 33 per cent. in the proportionate amount of solid raised. Therefore the standard rate of payment would appear to lie somewhere between these two variables.

Without going into detail, it may be said that there are no practical difficulties in determining the density of each hopper fill without delaying the operations of dredging. How real the present difficulty of establishing a basis of contract is may be ascertained from such existing literature as there is. On January 9, 1917, Mr. William Brown, M.Inst.C.E., read a valuable paper before the Institution of Civil Engineers (*see* vol. cciii, page 212) on "Recent Progress in Dredging Machinery," and the ensuing discussion produced most emphatic comments from the late Sir William Matthews, K.C.M.G., and Sir Cyril Kirkpatrick, K.B.E., now Chief Engineer to the Port of London Authority, on the necessity of reaching some agreement as to standardising a method of measuring quantities of dredged material. At a later date (on December 15, 1922) Mr. Gascoigne Lumley, I.S.O., read, at the Institution of Mechanical Engineers, a paper on "Reclamation Plant and its Operation," and this paper had the principal value of again provoking a discussion on this same difficult problem.

Whenever a riverine harbour is found to be silting up, or deeper channels are required in the fairway for navigation purposes, the authorities are immediately faced with the old question, viz.: that of the most economical disposal of the sludge. There are only a few rivers in the British Isles where it is practicable to dump sludge ashore, and, in cases where this is possible, it does not follow that it is always cheaper than taking it to sea.

At first sight there would appear to be no question at all that a sea trip for each hopper would be much more expensive than merely taking the hopper alongside a reclamation vessel adjacent to the foreshore and pumping the contents ashore. This would certainly be the case, if there were no questions of land drainage, retaining walls and pumping plant, &c., to be considered.

It is a very great mistake (except in exceptional circumstances) to put a pumping plant in a fixed position as this means the pipe line going ashore has continually to be lengthened and altered as to position. If pumping sludge ashore is to be carried out at all it is always best to have the pumping plant afloat as the reclamation vessel then is free to move up and down river and lie opposite any site where it is required to dump the sludge.

In the case of the river Thames, the Port of London Authority find it cheaper to take their sludge to sea where it is deposited in the "Black Deep," approximately 66 miles below London Bridge and Sir Cyril Kirkpatrick gave valuable data in regard to dredging in the Thames and London Docks during the discussion on Mr. Lumley's paper, referred to above. He then stated that the total working cost of dredging and depositing at "Black Deep" was about $\frac{1}{8}d$. per cubic yard, and explained why it is cheaper to carry sludge to sea than to deposit it on the foreshore or behind the banks of the Thames.

There are thousands of acres of marsh lands in the County of Essex below high water mark which would be excellent sites for reclamation—but it would be quite impossible to carry out this work at $\frac{1}{8}d$. per cubic yard. Most navigable rivers have low lying lands towards their mouths, and the watershed of the surrounding higher land is drained through fleets and small streams to the main river. It would naturally follow that, if millions of tons of dredged matter were deposited behind the banks of such rivers, these outlets would be blocked up, and consequent land flooding would take place unless innumerable culverts were constructed, and the cost of this work might well prove prohibitive. It is an interesting reflection on this point that the 4,000,000 cubic yards of dredging which comes annually from the London Docks and the River Thames would absorb roughly a square mile a year in reclamation areas on an average fill 3 ft. deep.

At Belfast all dredged material is ultimately to be pumped ashore at an expected maximum output of 18,000 tons per week, and none, for some time in the future, will, it is hoped, have to be carried to sea. The conditions are, however, entirely different to those on the Thames where, generally speaking, until recently the Port of London Authority held practically no freeholds of riparian lands in the estuary.

Just how much of dredged material which is dumped at sea is brought back into river estuaries by flood tides is another matter for conjecture, and many opinions have been expressed on this matter in regard to the Thames.

Any reclaimed land must naturally be allowed to lie fallow for some years to allow it to "settle" before it is of any use for building purposes unless piled foundations are resorted to. It is more satisfactory for all concerned, *where it is possible*, to use the dredged material for the purposes of reclamation, as it is then feasible to avoid sea-going voyages by hopper and at the same time to create remunerative industrial lands. In nine cases out of ten, therefore, reclamation must naturally be associated with the possibility of collateral deep water quay accommodation being afforded along the banks of the newly made lands.

When reclamation work of this character is projected, there nearly always arises the question of measurement and payment, because two operations become involved and visible to the eye, viz. :—(*a*) The actual work of dredging. (*b*) The amount of solid deposited on the reclamation area. The scale of payment under (*a*), subject to suitable reductions, can clearly still be based, though not directly, on the density of the sludge raised. A difficulty, however, nearly always crops up under (*b*) and two methods are frequently adopted. One is to take soundings over the dredged area and to compute the amount of solid removed from the river bed and put ashore. This is unsatisfactory, because often a proportion of alluvium, silt, or gravel as the case may be, is washed into (or slips into) the dredged area before soundings can be taken.

The other method is to take levels on the reclaimed area before and after pumping the sludge ashore. This is still more unsatisfactory, as apart from the long time which has to elapse before the material dries out and settles, there remains the "allowance for settlement" which varies with the depth of fill at any particular point and the nature of the soil below which is frequently soft and variable on river banks or foreshores. The only practicable method is clearly, therefore, to base the rate of payment (*b*) *directly* on the solid raised as determinable from the density of the sludge, examples of which have been given in the table above.

In places where trade is springing up and where there is no suitable land in existence on which to build factories, the possibility of reclaiming land is naturally at once thought of. In the case of reclaiming foreshores, unless there are very good reasons to the contrary, it is always unwise to construct temporary retaining walls, banks or

bulkheads behind which the sludge is to be dumped. It is more economical in the long run to construct a permanent barrier between land and water in the first instance. If a temporary bulkhead, which at a low cost generally means a weak design, is erected there is every possibility of its total collapse—owing to the very great lateral thrust set up by the pressure of the mud behind. Should this happen after a long period of work, it means that every penny spent from the commencement of the work may be lost, as the tide will enter and duly remove dredged materials that have already been dumped. Another error is sometimes the construction of a clay or stone embankment. Every tide will wash over this or around the scar end during construction and the usual marine troubles and difficulties experienced in works of this class are likely to be emphasised.

Further, when the temporary embankment is built, the work is only half done; no shipping can come alongside and deep water quays have still to be built. If, in the first instance, a good solid retaining wall or quay with a bulkhead is constructed it will perform the dual functions of holding up the filling behind, and accommodating ships alongside. Another matter not to be lost sight of is that you can dredge at once alongside permanent works of suitable design and depth whereas you cannot dredge along the toe of an embankment. The design and construction of permanent bulkheads must, however, be approached with great care. The pressure of liquid mud has been known actually to squeeze down under the foundations and turn a retaining wall, over—but more usually it will push it forward and out of alignment. A method sometimes adopted to prevent this is that of driving sheet piles behind the wall to a sufficient depth, as ascertained by previous borings.

Retaining walls are sometimes constructed by driving reinforced concrete piles with stays and back platforms to take the weight of the sludge and provide a righting moment behind the face. A deep wall of this type was built and constructed at Carnarvon Harbour a few years ago. Many remarkable cases are known of failures of solid fill quay walls—perhaps the most striking being the case in 1908 when the whole side of a mass concrete graving dock at Naples slid inwards under the pressure of the outside water and newly-formed filling. (See communication by Dr. Luiggi to the Institution of Civil Engineers, page 182, vol. ccxiii). The cause of this accident was put down to the pressure of water and earth filling outside, beginning to cause a small fissure between the invert of the dock and the retaining wall founded on it. Upward pressure was then gradually developed increasing the fissure, and finally detaching the wall from its foundations. The water and mud pressure from behind then moved it bodily forward causing the wall to slide along the invert of the dock till it stopped in an almost vertical position against the other side of the graving dock. The enormous block of concrete put in motion, Dr. Luiggi states, was about 400 ft. long—30 ft. high and 15 ft. wide at the bottom. It moved approximately 40 ft. It broke into several pieces—but each piece moved remained almost vertical!

Many methods have been attempted for pumping sludge ashore—but again this is a matter which must be finally governed by the nature of the foreshore or marsh lands. Some eighteen years ago an attempt was made to pump sludge ashore at Southwold, Suffolk, with the idea of deepening the river Blyth and reclaiming adjacent lands. The final result as regards pumping ashore was a complete failure. The idea was to pump the sludge ashore through a floating pipe line and the reasons for failure were given in a recent communication to the Institution of Mechanical Engineers and were thus put on record:—"(*a*) The material dredged was glacial drift containing boulders: the smaller of these passed the separator and constantly damaged the pug-mill. (*b*) The flexible joints on the floating pipe line involved at each joint a momentary increase of cross-section of over 50 per cent. The resultant hydraulic head opposed to the centrifugal pump was thus constantly raised by shock losses at the joints. (*c*) The joints in the pipe line became the points of deposit owing to locally decreased velocities, and the pipe-line became "snaked" in profile as the buoys carrying the pipe were inadequate to support unequal loading. (*d*) A definite vertical head at the land end of some 13 ft. over the river wall was apparently overlooked when the duty of the plant was calculated. The net result was the complete failure to perform the required duty of 1,400 cubic yards per day of ten hours of sludge deposited on the marshes, and the scheme was finally abandoned."

As a contrast to this failure are the very excellent results obtained in the Lake St. Peter Channel of the River St. Lawrence. A paper was read before the Canadian Society of Civil Engineers in 1904 by Mr. A. W. Robinson, M.Can.Soc. C.E., in which he ably explained the details. The Lake St. Peter Channel was part of the improvement scheme for the navigation of the river St. Lawrence between Montreal and Quebec. The work had for its aim the purpose of getting ocean-going vessels to Montreal, making that city the point of transhipment between the inland lake and rail traffic via the St. Lawrence to the Atlantic. This section of river is 160 miles long between the cities named of which about 60 miles is dredged channel in about 20 different sections. Floating pipe lines were used through which the sludge was pumped. The form of pipe line adopted was that of a central conduit 36 in. diameter carried by two cylindrical pontoons or air chambers 42 in. diameter—one on each side of each length of conduit, the three being bound together by truss-frames in steel. The truss frames were so constructed that they could be clamped to both conduits and pontoons, and in this way no rivets or bolts had to be put through the air chambers. The pipes were made in 100-foot lengths.

At first the sections of pipe-line where great flexibility was required were made up in four sections of 50 ft. This, however, was found to be unsatisfactory as the shorter length of pipe did not stand the sea as well as the 100 ft. sections and, moreover, it was found that sufficient flexibility could be had without them. The shorter lengths were, therefore, joined together to form 100 foot lengths. There has always been considerable difficulty experienced in designing joints for these floating pipe lines, but those designed by Mr. A. W. Robinson proved to be satisfactory in all respects. His design was as follows:—The central conduits or pipes were joined together by rubber sleeves with about 4 ft. clearance between the pipe ends. Two channel irons were laid longitudinally above the air chambers resting on timber stools (or distance pieces) shaped to fit the curved air chambers. These channel irons were broken at the centre and stopped off flush with the face of the conduit on each side of the joint. Both sets of channels were clamped down to the air chambers by steel bands. The channel irons were finally fastened together by means of a ball and socket joint, the ends of the socket attachments being bolted on to the webs of the channel irons.

The dredger was originally designed to work at a depth of 50 ft. and had an average output of 2,500 cubic yards per hour. The material met with, varied from soft clay to slate, rock and stones, the dredgers themselves differed, therefore, in their character for the different sections of the work. Mr. Robinson states that the average cost of one cubic yard was $1\frac{3}{4}$ cents—but this brings us back to the point previously raised, as to what a cubic yard of dredged material really is!

The pipe-line was designed so that it was two-thirds submerged, in order to render it less exposed to the wind and waves. The weight of a large steel pipe filled with water and dredged material is great, and would require large pontoons to carry it *above* water—but by partially submerging it, the upthrust required to secure buoyancy is much reduced. In the case of the Lake St. Peter Channel the dredged matter was not pumped ashore—being merely removed from one part of the river—or channel—and deposited on adjacent sites where obstruction to channels would not be caused. The actual length of flexible pipe-line was about 2,000 ft. The St. Lawrence dredging is quoted at some length, as it has deservedly proved most successful and it is possible, similar methods might be adopted with advantage in some of our home waters.

METALLURGY AT THE BRITISH EMPIRE EXHIBITION.—VII.

The metallurgical exhibits of Messrs. Cammell Laird and Co., Limited, have been manufactured at their establishments in the Sheffield area, the Cyclops, Grimesthorpe and Penistone Works, and by the Newlay Wheel Company, Limited, of Leeds, one of Messrs. Cammell Laird's associated companies. These exhibits are displayed around the facsimile of a 170-ton steel ingot, and include a cast-steel autoclave having a capacity of 275 gallons, weighing about 7 tons, for use in the manufacture of dyes; this piece has been tested to a pressure of 2,000 lbs. per square inch. Near this are sets of rolled steel locomotive, carriage, wagon and tramcar tyres, varying in weight from 1 cwt. to 15 cwt., the series comprising locomotive tyres 6 ft. $2\frac{5}{16}$ in., 5 ft. $1\frac{13}{16}$ in., 4 ft. $1\frac{5}{16}$ in., and 3 ft. $2\frac{5}{8}$ in. inside diameter for British railways, besides a tyre for Indian railways 2 ft. inside diameter. The locomotive, carriage and wagon tyres are made of steels which give a tensile test of from 42 to 69 tons per square inch, with 18/8 per cent. elongation on 2 in., according to the class of tyre. The firm's tramway tyre steel has a tensile strength of 60 tons to 70 tons per square inch, with 8 per cent. to 6 per cent. elongation. A wagon tyre for a British railway measures 2 ft. $7\frac{13}{16}$ in. inside diameter. A pony wheel tramway tyre, "Camel" brand, has a tensile strength of 70 tons to 75 tons per square inch. A rolled steel angle ring for boiler work, and an angle dome ring, both on the stand, have a tensile strength of 26 tons to 30 tons per square inch, with 22 per cent. elongation. A carriage tyre for electric railway service has been satisfactorily tup tested, the tup weighing 1 ton and falling on the tread from heights of 10 ft. to 35 ft., the deflection at 10 ft. was $\frac{1}{16}$ in., at 15 ft., $\frac{1}{8}$ in.; at 20 ft., $\frac{7}{16}$ in.; at 25 ft., $1\frac{1}{4}$ in.; at 30 ft., $1\frac{7}{8}$ in.; and at 35 ft., $2\frac{1}{16}$ in., the tyre being unbroken. The rail specimens exhibited include a 95 lb. British Standard rail with tail fishplates, and a 95 lb. British Standard rail with ordinary fishplates; other rail sections are also shown, among which may be mentioned flat-bottomed rails weighing 106 lb. downwards to the smallest sections for pit and contractors' work. There are also shown tramway rail specimens with the Bolton patent welded joint, tramway rails and fishplates, soleplates for light-section rails, hollow-bridge rails weighing 72 lb. per yard, also solid-bridge rails, the weight of which is 110 lb. per yard, and special rails for gas-holders. Other rolled steel material includes glazing bars, sleepers for light railways, &c.

A turning from a mild steel shaft of 28/32 tons tensile strength is exhibited; this was obtained at a cutting speed of 30 ft. per minute, the depth of cut being $1\frac{7}{8}$ in., and the traverse $\frac{1}{4}$ in. per revolution. A number of tool steels are displayed in a show case, together with exhaust and inlet valves of steel specially resistant to the erosive and scaling influences of high temperatures. The excellence of Messrs. Cammell Laird's steel castings is well illustrated by their exhibits of railway wheel centres, some of which have been cut and bent cold, clearly illustrating the ductility and soundness of the casting, whilst others have been subjected to heavy tup tests and reveal no sign of fracture. Their other steel castings are in great variety, and cover a large number of industrial purposes. Their display of springs is also very comprehensive and includes railway springs of all types, one, a laminated bearing spring for a 10-ton wagon having had 24 years' continuous service. The exhibits of railway axles include a tested motor coach axle for electric railway service; this received first five blows from a tup weighing 1 ton, falling 35 ft., the axle resting on a support 5 ft. between centres, and was then bent double cold, both tests having been satisfactorily withstood as can be ascertained. The display made by the Newlay Wheel Company, Limited, above referred to, is a series of solid forged and rolled railway steel wheels, of acid open-hearth steel, in one piece each, the flanged rim being integral with and stiffened by the web. The wheel is first forged in enclosing dies under a 7,000-ton press and afterwards rolled to approximately finished dimensions. The specimens on the stand include 43-in. dia. and 38-in. dia. carriage wheels,

and one of 28 in. for carriage, brake-van or wagon, together with a half-section of a tramway wheel as supplied to tramways in Great Britain, South Africa, Australia and New Zealand. An interesting exhibit from these same works is a 38-in. diameter wheel worn down to 35¼ in. in diameter. This wheel has been in continuous service from 1910 down to last June under a heavy goods brake van, on the North British Railway, the wear amounting to $\frac{1}{8}$ in. in diameter per annum.

The display made by Messrs. Stewarts and Lloyds, Limited, whose London offices are at Winchester House, Old Broad-street, E.C. 2, contains a representative selection of their lap-welded and weldless pipes and tubes, tubular steel davits, tramway poles, specimens of cylinders, coils, &c. The framework of the stand is formed of 10-in. and 6-in. flanged steel pipes, flanges and bends; the name of the firm is made of 1-in. gas tubes and the handrailing of 1¼-in. similar tubing. The items on the stand are in great number. They include a 24-in. bitumen-lined steel pipe, 19 ft. in length, and a 27-in. cement-lined steel pipe, the length of which is 22 ft., both of which are illustrative of the firm's work for water-supply undertakings. Another specimen is a steel pipe, 48 in. in outside diameter and $\frac{15}{16}$ in. in thickness, made up of two pieces joined together with the Vulcan joint, the pipe exhibited being 12 ft. in length overall and representative of the firm's pipe lines for hydro-electric plants. Three 12-in. pipe sections, each 3 ft. long overall, for low-pressure gas and water mains, are shown, with three kinds of joints, the collar joint, lead and yarn joint, and long-sleeve lead and yarn joint. Examples are also exhibited of the Victaulic flexible and other joints. The display is indicative of the firm's activity in the matter of pipe and tube manufacture for every branch of industry. Messrs. Stewarts and Lloyds supplied and erected the main steam steel pipe installations in the boiler and power houses of the exhibition. The stand also contains miscellaneous steel castings, a cast-steel turbine bucket wheel, the steel of which has a tensile strength of 48 tons per square inch, with 18 per cent. elongation on the British standard bar, numerous test pieces showing the quality of the material; a steel billet weighing 1 ton, a bloom pierced from a similar billet, and a piece of finished tube serve to illustrate the gradation of the process of tube manufacture.

A representative exhibit of cold and hot drawn weldless steel and lap-welded iron and steel tubes and pipes, for gas, steam and water installations, for boring and oil pipe lines, is made by Messrs. John Russell and Co., Limited, of Walsall, Wednesbury, and Birmingham. Their stand further contains bases and finials for tramway poles as supplied by them to the Hull and other Corporations, various examples of seamless steel coils, superheater elements, a number of steel flanges, an example of the Victaulic joint, &c. They manufacture at their Birmingham works all classes of brass taps and fittings, numerous specimens of which can be seen on the stand.

The stand of the Monk Bridge Iron and Steel Company, Limited, Leeds, situated almost in the centre of the Palace of Engineering, contains a display of rolled-steel tyres from 1 ft. 1 in. to 7 ft. 6 in. in diameter, rolled steel ball races, angle and dome rings from 2 ft. to 7 ft. in diameter, rolled-steel rings 14 in. deep, finished locomotive crank axles, engine, carriage and wagon axles, locomotive motion levers, piston rods and connecting rods, models of various forgings, samples of Best Yorkshire iron forgings, ornaments showing the forging properties of Best Yorkshire iron and test pieces of iron and steel.

Messrs. Wilkins Wire and Wire Ropes, Limited, Eastwood, Notts, have displayed a showcase of wire ropes which were at the London Exhibition of 1851, and comprising samples of copper ropes and of iron wire ropes, as there was no steel wire drawn at that period. The works were formerly at Wapping, London, where the first submarine telegraph cable laid between England and France was manufactured at the same early period. Another showcase contains specimens of the firm's present-day steel wire ropes for engineering and mining purposes, ships' cables and ropes, &c. Another exhibit is a model of a wire suspension bridge, which forms an inexpensive and easily erected means of communication across rivers and gorges in outlying and sparsely-populated districts.

A very striking display is made by the Steel Company of Scotland, Limited, in one of the annexes of the Palace of Engineering. The stand itself forms part of the exhibit and is built of four columns carrying a superstructure made up of rolled plates, channels and sections. The columns have cast-

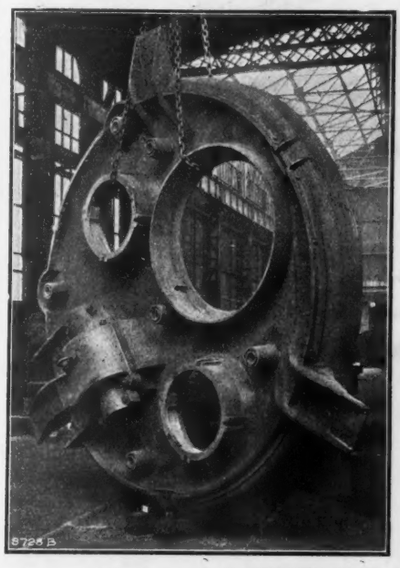


FIG. 4. CAST-STEEL TOP PLATE FOR GAS PRODUCER PLANT.

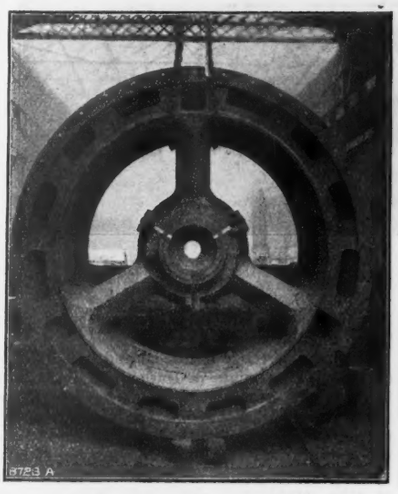


FIG. 5. CAST-STEEL AIR-BLAST SPIDER FOR GAS PRODUCER PLANT.

iron bases and caps, and the vertical members are made of some of the many sections rolled by the firm, such as channels, angles, bulb angles, rails, &c. The columns are joined by horizontal channel bracings to which are fixed thin section pieces of the various rolled bars manufactured by the company. Some admirable specimens are shown on the stand. They include a top plate for a gas-producer plant, in cast steel, the diameter of which is 11 ft. and the weight 58½ cwt.; it is illustrated in Fig. 4. Another example of the Steel Company of Scotland's steel castings is an air-blast spider, also for a gas-producer plant; this is 10 ft. in diameter and weighs 77¾ cwt. and is shown in Fig. 5. Both these pieces are striking examples of the progress achieved in recent years in the manufacture of steel castings. Other steel castings exhibited are two rolling mill pinions, one having straight teeth and one helical teeth; two-wheel centres for locomotives; a horn-block and a slide-bar bracket for locomotives; a steam valve body for a marine engine; a dredger bucket back; a quadrant and tiller for ship steering gear, and a ship mooring chain. The company's activity in the manufacture of steel castings is further illustrated by a number of models of ship component parts, stern frames, propeller shaft brackets, &c., the weights of which range from 3 tons to 30 tons. The work of the company's rolling mills is depicted by boiler plates for 14 ft. marine boilers; a rolled steel shell boiler plate 12 ft. wide and 1·5 in. thick; a flanged lower front having three furnace holes; a back-tube plate and a back-combustion chamber plate. Their pressed steel work specimens include two motor-car chassis members of 28-32 tons and 32-36 tons tensile strength, and a nickel-steel motor chassis member having a 36-40 tons tensile strength. A number of tyres are shown, comprising locomotive driving tyres, carriage, wagon and tramway tyres, the dimensions of which varies from 6 ft. 2¼ in. inside diameter down to 1 ft. 7½ in., made of various grades of steel to suit the conditions required in each particular case. In various parts of the stand are forged steel locomotive crank and straight axles finish machined; two forged steel wagon axles and two other similar axles bent cold. Photographs and models are displayed, among them being one of a pair of rolling mill housings, each weighing about 60 tons.

In several of our former issues we have called attention to the British Chemical Standards, and to the work carried out in this connection by Messrs. Ridsdale and Co., the well-known consulting and research chemists of Middlesbrough. The chemical standards act as a valuable aid to analytical agreement, and the movement forms a link between firms in this country, and also between them and firms in the Colonies and Dominions, and in foreign countries. Engineers, manufacturers, buyers or sellers have now at hand the means of knowing exactly what is the definite value of a stated composition, and they can refer their specifications to a specific standard obtainable by the maker or by the referee. The standards can be viewed in the light of templates for checking purposes. This makes for thorough co-ordination of chemists' work, and sets aside many difficulties occurring in the acceptance of the material. So far, the standardised specimens number 90, and the standards are used by 600 works and independent analysts at home and abroad, and also by universities. With every portion of a standard a certificate is issued giving the names of the co-operators, the method used by each analyst, his own results and the average of all. The standards are obtainable from Messrs. Ridsdale, Messrs. Baird and Tatlock (London), Limited, and through agents in India and on the Continent. The work in connection with the standard is carried out by a number of co-operators, manufacturers and chemists, including the organisers, Messrs. Ridsdale and Co., who give both material and service for forwarding the movement, which is voluntary and unsupported by any grant. Messrs. Ridsdale and Co. show on Messrs. Baird and Tatlock's stand in the Chemical Section of the Palace of Industry, a number of standard steel specimens. Another exhibit similarly aiming at unification of analytical results illustrates the "Analoid" system of analysis already adopted for steel, iron, slag, &c.

The stand of Messrs. Baird and Tatlock (London), Limited, above referred to, contains a variety of scientific apparatus and articles manufactured by them. Among the principal items in the display are electric centrifuges large and small, autoclaves for pressures from ½ atmosphere to 8 atmospheres, apparatus for bio-chemical analysis, &c. They also show fine chemicals refined in their own laboratories. The firm's speciality is the complete equipment of laboratories for inorganic and organic chemistry, physiology, the biological sciences and physics, their work in this respect covering practically every trade.

The stand in the Palace of Engineering in which are contained the exhibits of Messrs. Dorman,

36-IN. GEARED SENSITIVE RADIAL DRILL; THE MACHINE TOOL EXHIBITION.

CONSTRUCTED BY MESSRS. FREDERICK POLLARD AND CO., LIMITED, ENGINEERS, LEICESTER.

(For Description, see opposite Page.)

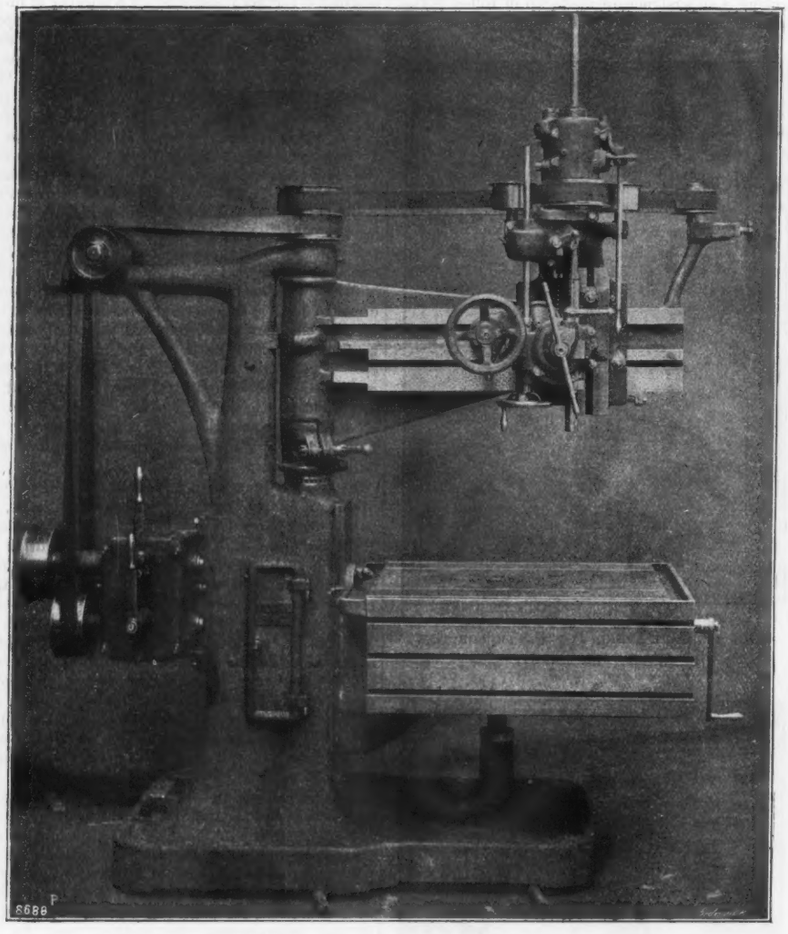


FIG. 184.

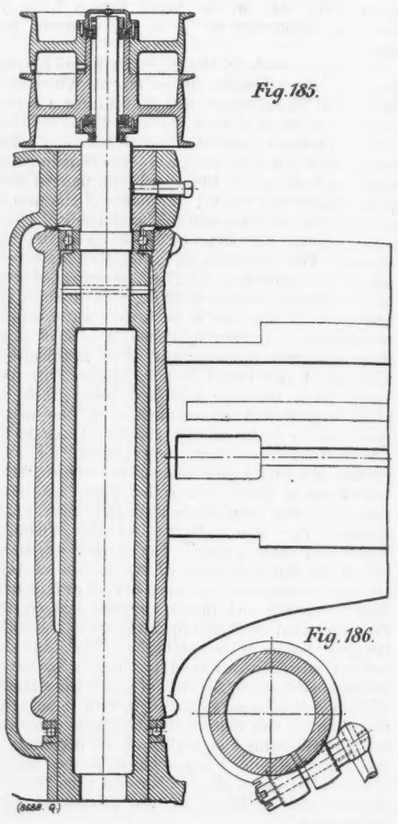


Fig. 185.

Fig. 186.

Long and Co., Limited, has been designed by Sir Edwin Lutyens, and represents in itself an interesting exhibit of modern steel construction. It consists of eight columns supporting a roof; the columns and roof are formed of steel girders, encased in "scagliola" marble—a marble substitute—and Portland stone respectively. The inner side of each column and of the entablature has been left open to show the various riveted connections of the steelwork.

Besides being steel manufacturers, owning coal and ironstones mine, and also producing steel from their own raw materials, Messrs. Dorman, Long are constructional engineers and bridge builders, undertaking contracts for the supply, and, if necessary, the erection, of steel frame buildings, bridges, pipe lines, and tanks, at home, or in any part of the world. They own large constructional shops at Middlesbrough, others at Nine Elms, London, for fabricated stanchions and girders for buildings, besides branches, with constructional shops in Australia, and fully equipped associated companies in India, South Africa and South America. Examples in London of this side of the firm's work are the steel frame of Bush House, London (2,400 tons of steel), of Lyons' New Corner House (2,400 tons), and the block for the Liverpool Victoria Friendly Society in Southampton-row (5,500 tons), now building. They secured the Sydney Bridge contract early this year, as stated on page 129 *ante*. A water-colour drawing of their accepted design forms a feature on the stand.

The exhibits range from coal and iron from the company's own mines in Durham, and Cleveland, through pig iron and ferro-manganese (Carlton brand) to steel. Representative of the company's output capacity of 1,000,000 tons of finished steel per annum is a 10-ton ingot and a pylon of billets of many special grades of steel for the manufacture of axles, crank pins, draw bars, bolts and nuts, hammers, shovels, chisels, springs, saws, rifle barrels, shells and motor car bodies. Of particular interest to engineers is the display of sectional material embracing the full range of British standard beams (29 sections), channels (18 sections), equal and unequal angles (36 sections), bulb angles and tees (28 sections). Of these the company produce upwards of a quarter of a million tons annually. There are also specimens of pressed plate and rolled steel troughing for the flooring of buildings and decking of bridges, and a wide range of flat, round and square bars. The company also show typical specimens of British Standard bullhead and flange rails, as well as many interesting sections rolled for railways and tramways abroad, and conductor rails for electric railways. In this last category may be mentioned a rail of unusual section for the Central Argentine Railway, and the new 150-lb. conductor for the suburban lines of the Southern Railway of England. There are, further, examples of fish plates and sole plates and two complete rail joints, one a Standard British section, the other for the Great Indian Peninsula Railway. Other exhibits are bridge rails, and light colliery rails, and a number of small special sections, whilst of particular interest are some specimens of Dorman, Long and Co.'s steel bent cold, to show the great ductility and strength of the material.

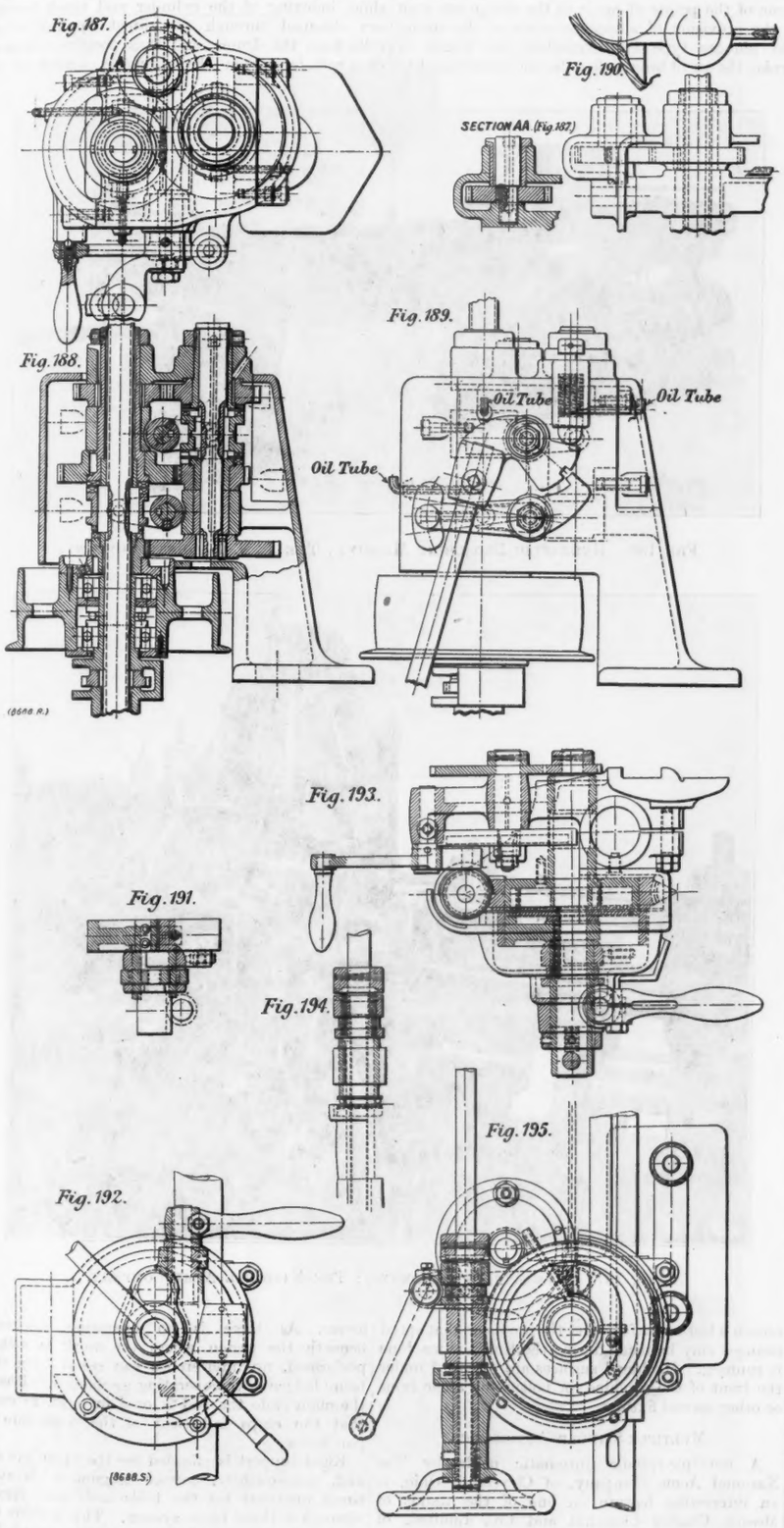
The company's Redcar Works, near Middlesbrough, are entirely devoted to the manufacture of steel plates for shipbuilding, and constructional work generally, in widths up to 9 ft. and lengths up to 100 ft., and from $\frac{3}{16}$ in. to 2 in. in thickness, and to the manufacture of universal mill plates for bridge building and structural work. These universal plates leave the rolls ready for use, thus doing away with the necessity of shearing and edge planing by the user. They are produced in lengths up to 90 ft. and thickness to 2 in. A very attractive exhibit of these universal plates occupies an important position on the stand, while specimens of the 72 in. and 57 in. diameter pipe lines for the Bombay water supply contract* show one of the uses to which the steel plates have been put with great success in recent years.

Messrs. Dorman, Long and Co. have a very large output of galvanised and black steel sheets for roofing and other purposes, and show an attractive range in various widths and thicknesses. These sheets, like the bulk of the company's wire production, are for export to India and South America, and to ranching districts generally. A case contains specimens of the company's galvanised steel hawser wire, to Lloyds' tests, plough steel wire for colliery guide and lifting ropes, railway signal wire, telegraph and telephone wire, rigging wire, wire for submarine cables, and all grades of drawn

See ENGINEERING, vol. cxvii, page 315.

SENSITIVE RADIAL DRILL; MACHINE TOOL EXHIBITION.

CONSTRUCTED BY MESSRS. FREDERICK POLLARD AND CO., LIMITED, LEICESTER.



fencing wire, as well as steel rods for reinforcement of concrete. A very interesting series is shown of the firm's by-products from their coke manufacture. These by-products include, among others, coal tar, of which the company produce 60,000 tons annually, pitch, creosote, benzol (3½ million gallons annually), sulphate of ammonia (17,500 tons) and naphthalene.

MACHINE TOOL AND ENGINEERING EXHIBITION.—IV.

WE now conclude our notice of the Machine Tool and Engineering Exhibition which closes to-morrow. Although, in spite of the fact that we have devoted a liberal amount of space to this excellent display we have only been able to deal in many cases with typical examples of exhibits, we have endeavoured to make our accounts as representative as circumstances have allowed. It is satisfactory to think that the impression on the whole appears to be that the exhibition from a business point of view has been successful, and that the right type of visitor has attended in sufficient numbers to bring some ray of hope to the manufacturers. When the show is considered as a whole, although there are absentees, it must be confessed that the display has been excellent and representative of one of our finest industries. The quality and finish of the machines can only be classed as excellent, while the developments in design are both interesting and attractive. Briefly, the engineering points of a general class which are most noticeable include the larger use of ball and roller bearings, of splined shafts and spiral bevel gears. The electric motor drive and various types of control, including the push button at the machine itself, is noticeably more frequently adopted than hitherto, while the application of gear boxes is spreading with a view to increasing the flexibility of many machines and eliminating belt troubles, &c.

DRILLING MACHINE.

A high-speed ball bearing sensitive radial drill fitted with gear box, is illustrated in Figs. 184 to 195, on this and the opposite pages. This is a 36 in. heavy duty drill by Messrs. Frederick Pollard and Co., Ltd., Leicester. It has automatic as well as sensitive feed, and tapping reverse. It is intended for a drilling up to 1¼-in. holes. A single-pulley drive is taken to a gear box on the column. The box is similar to the one of which we gave drawings last week and described on page 407. It is provided with two levers and four expanding clutches, the gears being always in mesh, and giving with the saddle gears eight spindle speeds. The pillar is made of cast-iron and is provided at its upper end with a large steel shaft, which is driven into the cast-iron part of the pillar, and cottered. The lower end of the pillar is fixed in the main frame. At the upper end a collar held in the frame supports the shaft and takes care of upward lift of the arm. The pillar is ground on the outside and the sleeve of the arm fits over it (Figs. 185 and 186), being provided at the lower end with a ball-thrust bearing, and at the upper end with a bull-journal bearing. An extension of the pillar shaft accommodates two pulleys mounted on ball bearings and with ball-thrust bearings. The lower of these pulleys drives the upper, the pair transmitting the belt drive from the gear box to the saddle. The belt on the upper pulley is carried over a driving pulley for the spindle, and two idlers on the saddle give a long arc of contact. There is a further idler at the end of the arm. A tension screw is fitted to the latter.

Details of the spindle drive on the saddle are given in Figs. 187 to 190. The belt pulley, mounted on double ball bearings and with ball thrust washer, is shown in Figs. 188 and 189. The section, Fig. 188, shows the back-gear shaft and two sets of clutches operated by a short handle and long pendant lever, respectively. These levers and gears provide additional speeds and reverse. Above the pulley is a double-faced clutch worked by the handle shown in Fig. 187. The pulley drive is either direct through the lower clutch face to the spindle, or through the back gears if the upper face is clutched in. These, with the main change gear box, give the eight speeds. In order to complete the train for the drive through the back gears the small wheel on the back gear shaft has to be engaged by clutch. This is normally the case, an outside arm on the clutch lever being depressed by a spring plunger shown in Fig. 189. When this long clutch lever is raised, however, an upper clutch comes into action instead, and the drive is then taken from the top wheel on the back gear shaft through an intermediate

wheel shown in Fig. 187 and in a small detail in Fig. 190, and from this to the spindle, giving the reverse at an increased speed of 2 : 1. By means of the interlock on the ends of the clutch-operating levers (Fig. 189) the reverse can only be engaged when the spindle is on the lower range of speeds ; *i.e.*, when the spindle clutch is in the upper pinion. The group of small details to the right in Fig. 190 shows the oiling arrangement for the spindle wheel bearings.

Below the pulley is shown a small pinion which by means of a train of gears drives the feed shaft through a change-gear box. Details of the feed and cross axle are shown in Figs. 191 to 195. The feed shaft is shown to the left in Fig. 195, the spindle and quill to the right. Sensitive hand feed is by the usual handle lever, held in position by a friction block and spring. The feed can be operated by hand wheel shown at the bottom of Fig. 195, clutching this in by means of the slanting handle above. With this same clutch engaged the automatic feed can be brought into use by the movement of a horizontal handle shown in Figs. 192 and 193. This operates an expanding clutch by forcing a cone (Figs. 191 and 193) towards the worm wheel. This action, as explained in a former description, presses out an arm as a result of which two wings of the clutch are forced apart and against the internal surface of a drum on the worm wheel.

A depth stop and safety pin are arranged on the disc shown in Fig. 195. This disc is driven off the cross-axle (Fig. 193), the adjustable stop and safety pin knocking out the feed-shaft clutch when they work round to the limits for which they are set. The pin is a permanently set feature to prevent damage by overrunning. The depth stop can be set as required. The detail Fig. 194, shows the feed-spindle, clutch, ball-thrust washer, &c.

Broaching Machines.

Broaching is a workshop process which has become in recent years of greatly extended use and significance. For finishing holes true to form after rough drilling, for cutting internal keyways and other similar operations, the process is one for which claims may be made regarding the quality of the output and also the speed with which it is done, while the work is very simple to perform. Messrs. H. W. Ward and Co., Limited, of Selly Oak, Birmingham, have started as producers of broaching machines and exhibit their first model, a machine with a single pulley drive direct from an electric motor, which has four rates of traverse and a stroke of 44 in. This machine is shown in operation at Olympia broaching a 6-spline hole in steel blanks. Messrs. Alfred Herbert's broaching machine is also shown at work. This machine was illustrated in ENGINEERING, vol cx, page 339.

A good example of a broaching machine of American design is afforded by the exhibit by Messrs. Stockton and Bunn, Limited, of 11, Queen Victoria-street, London, of a hydraulic machine made by The J. N. Lapointe Company, of New London, Conn. This is illustrated in Fig. 196, annexed. For driving this an electric motor of 7½ h.p. is installed, and it drives directly a Hele-Shaw pump which supplies oil to the cylinder. The stroke of this machine is 4 ft. 8 in., and its pulling capacity is 36,000 lb. The oil supplied by the pump is passed to either side of the piston, and the output is controlled by the setting of the hand lever at the end of the machine. Adjustment of this is possible while the machine is pulling. The movement for the valves of the pump is obtained from a long side rod which receives motion at the end of the stroke, but only to an extent sufficient to meet the requirements. This can be varied at will by setting a collar on the side shaft at different positions. Once all the control arrangements have been set suitably to deal with a specific job, locking by means of pins is possible so that the machine then works continuously in the same way. The maximum cutting speed of the machine is 24 ft. per minute, while the return speed amounts to 60 ft. per minute. When it is stated that a 4-ft. broach is the normal length used with the machine, it will be appreciated that the return is accomplished in only 4 seconds. This machine is supplied with three reducing bushings that fit the bore in the face of the machine and four pull bushings for cutter bars. A pressure gauge is connected up to the oil system so that any irregularity in working due to the variation in the character of the material or the dullness of the broach may be instantly detected. Some of the points of merit in the design are seen in the provision of automatic stops of the spring and plunger type for controlling the length of stroke, the use of bronze shoes for the sliding head to obtain a lasting surface, and the provision that speed changes may be made during the time the machine is running. Machined surfaces are provided under the front of the machine for bolting on angle irons or other special fixtures.

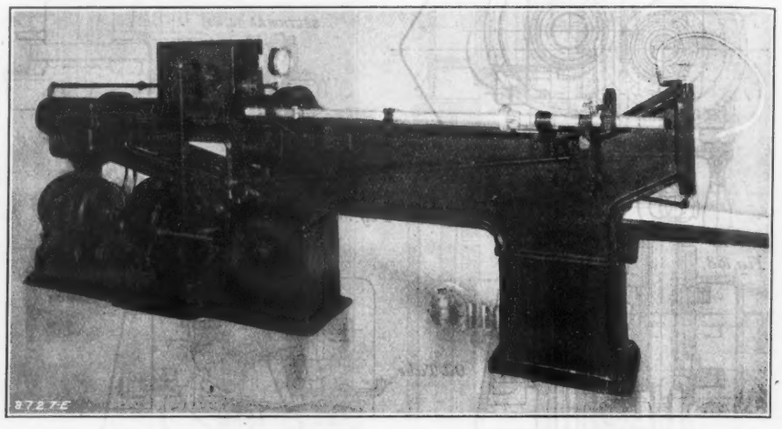


FIG. 196. HYDRAULIC BROACHING MACHINE; THE J. N. LAPOINTE COMPANY.

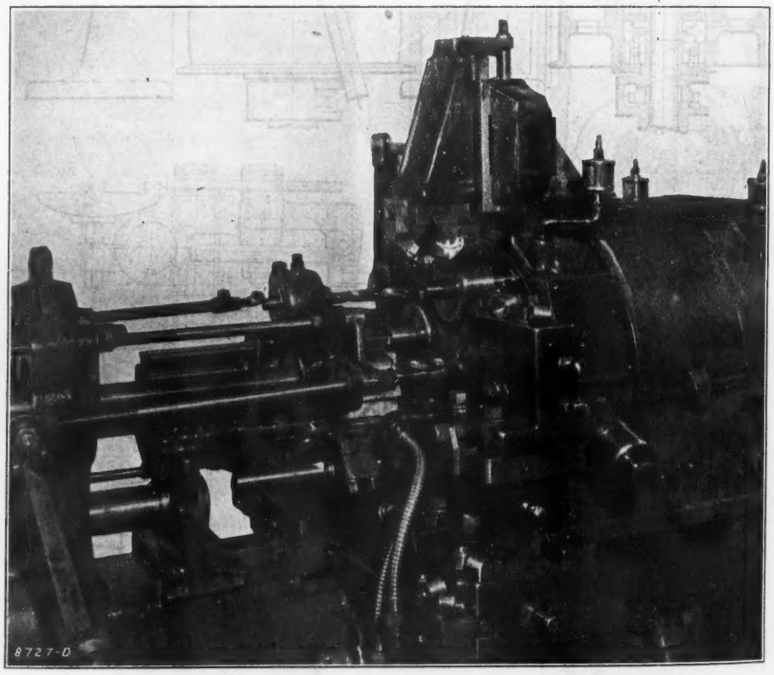


FIG. 197. FIVE-SPINDLE AUTOMATIC; THE NATIONAL ACME COMPANY.

Multiple-Spindle Automatic.

A multiple-spindle automatic made by The National Acme Company, of Cleveland, Ohio, is an interesting feature on one of the stands of Messrs. Charles Churchill and Co., Limited, of 9 to 15, Leonard-street, Finsbury, London. This has a chuck capacity of ⅞ in. for round material, of $\frac{31}{64}$-in. for hexagon rods and for square sections up to $\frac{25}{64}$ in. side. The machine is illustrated in Fig. 197, below, by a view showing it at work. The frame has five upright main supports which rest upon pedestals cast in the pan. The drums on the camshaft are under the bed construction, so that the camming for the feeds of the main tool slide, indexing of the cylinder and stock feeding are obtained through the direct application of rolls from the drums, and thus positive action is obtained free from the springing tendencies of levers. As there is no operating mechanism beneath the region where the work is actually performed, no interference can result from chips being lodged in the operating mechanism. Beneath the main slide the bed is oval in form, to ensure that the chips fall clear of the tools into the pan below.

Rigid support is afforded for the main tool slide and, consequently, correct alignment is at all times obtained for the tools and work spindles through a three point system. This consists of a hardened and ground slide extension, which telescopes into the spindle carrier at the front, a sleeve mounted on a heavy bearing in the frame at the back, and thirdly an extension of the pusher rod

SURFACE GRINDERS; THE MACHINE TOOL EXHIBITION.

CONSTRUCTED BY THE LUMSDEN MACHINE COMPANY, LIMITED, GATESHEAD.

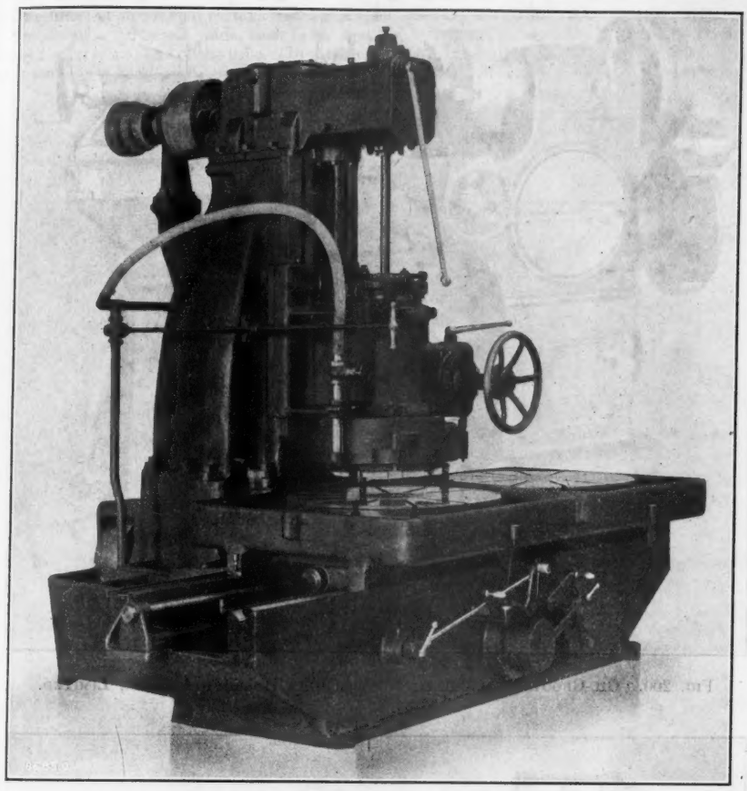


FIG. 198. TWIN TABLE VERTICAL SPINDLE GRINDER.

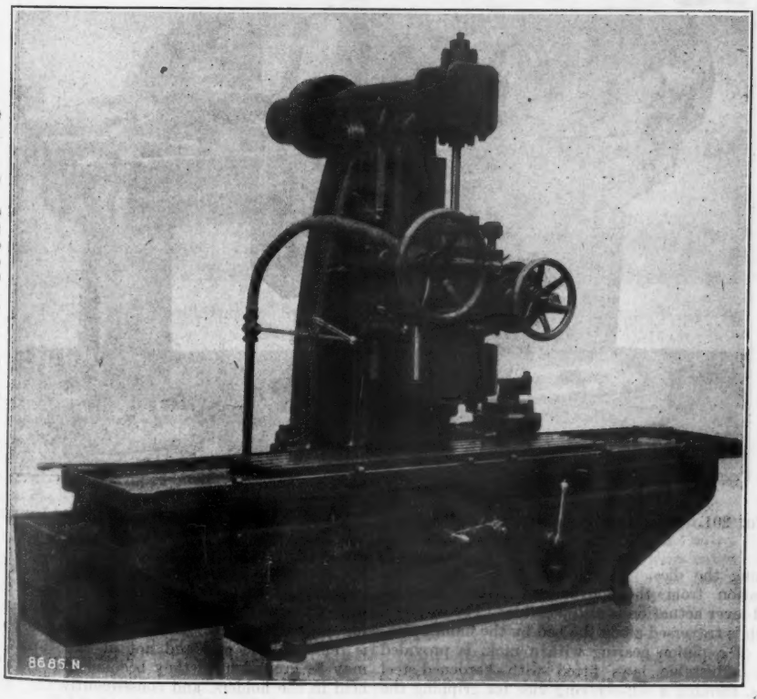


FIG. 199. SINGLE TABLE VERTICAL SPINDLE GRINDER.

into the frame independent of the carrier, which resists side thrust. The extension referred to travels along a hardened and ground steel plate through the centre of the bed. The slide pusher shaft also has its bearing in the frame and is operated direct from a roll by a lead cam on the main drum. An improved type of spindle carrier and casing is used. Of this the cylinder member is supported in bearings at either end, which have a total bearing surface, which is half the length of the cylinder. At both back and front, on top of the spindle carrier bearings, independent shoes provide the means of taking up excessive wear in the cylinder and casing. The casing is also counter bored at the front, and the cylinder set into the casing in such a way as to offer resistance to end thrusts. For taking up end wear three bronze shoes are provided in the rear of the casing. The spindle drive and the indexing mechanisms are situated between the spindle bearings. This arrangement makes possible the lengthening of the distance between the spindle bearings and the reduction of the overhang of the spindles where they extend through the spindle carrier. Hardened spiral gears with end thrust bearings are used for the spindle drive. These are driven by a shaft through the main tool slide. This construction assures constant, smooth and quiet running.

Since the machine has a capacity of 3,000 pieces per hour, the indexing of the spindle carrier must be performed at high speed, approximately once per second, and it is important to avoid strains at the pick up or shock at the stopping point. To meet these conditions it is arranged that the cam on the main camshaft engages in turn with three rolls on the index gear, which meshes with the spindle head to index it in one-fifth of its circumference. Security in locking the spindle carrier in positive alignment is also of importance, and this is accomplished by a new arrangement of lock and latch bolt. The latter is located on the rear of the machine and the lock bolt on the front. When in operation the lock bolt is withdrawn by a positive cam from one of the five notches in the cylinder at the instant of indexing, the latch bolt then rides up the slot on the opposite side of the head and springs into position at the next slot. Simultaneously the lock bolt, which has a tapered face is firmly settled into position by a positive cammed action without the use of springs. In this way both members, lock and latch bolts, have a tendency to pull the cylinder down towards the central bed construction, firmly fixing the relative position of spindles to the tools.

The bed casting carries hardened and ground steel bearing plates for the cross tool slides and thus is not subject to wear. Operation of the levers for these cross slides is obtained directly from a drum on the main camshaft with a positive feed through a hexagonal shaft. The forming and cut-off slides are of the same size and construction which makes them suitable for the arrangement of double-deck tooling. As the stock stop does not occupy one of the tool positions the use of tools is not limited to four positions but is available for all the five spindles.

VERTICAL SPINDLE SURFACE GRINDERS.

Two vertical-spindle surface grinders somewhat resembling each other are shown in Figs. 198 and 199, annexed. These are by the Lumsden Machine Company, Limited, of Gateshead. They are actually intended for quite different uses, the first having twin rotating work tables, while the second has a long reciprocating table. The former machine is designed with a view to eliminating waste time in setting up; the latter is for grinding long parts such as motion bars, as well as for gang work on smaller pieces of work. The twin-table machine shown in Fig. 198 has an 18-in. segmental wheel with a clear height under wheel of 18 in., or when fitted with a magnetic chuck, of 14 in. The diameter of the tables is 35 in., and they will carry magnetic chucks 36 in. in diameter. The drive is by belt to the top of the column. The drive is transmitted to the wheel by spiral bevels. The spindle is carried in ball and roller bearings. The saddle is raised and lowered by power, and the ram has self-acting feed of 1½ in. The rotating tables have six speeds

controlled by friction clutch. These speeds are derived from cone pulleys and a gear-box. The table is traversed by power, and both rotary and traversing motions are engaged by friction clutch.

The machine illustrated in Fig. 199 uses a 12-in. wheel, the area of the table being 66 in. by 12 in. The maximum height under the wheel is 16 in. The table can be traversed at 7½ ft. and 30 ft. per minute through a two-speed gear-box, the table drive being to a large worm on an oblique shaft engaging with a straight rack under the table. The saddle has vertical adjustment by power, and the ram has a feed of 1½ in. by an adjustable ratchet gear giving from 0·002 in. to 0·024-in. feed per stroke, regardless of the shifting-belt mechanism driving the table. The table drive is taken by open and crossed belt from the main pulley spindle to a box at the back of the machine, and the ratchet feed is operated from this.

Oil Groove Cutting Machine.

For the cutting of oil grooves either externally or internally, Messrs. John Holroyd and Co., Limited, of Perseverance Works, Milnrow, Lancs., have produced a machine which will cut a groove 12 in. long, which they exhibit. This is illustrated by a general view in Fig. 200, annexed. With it any class of work may be cut, for it will groove equally well in cast iron, steel or bronze, and produce cuts either straight or spiral, crossing or not, to meet all requirements. Not only is the work done by such a machine productive of great savings in time as compared with cutting by hand, but as the grooves produced are uniform in depth and regular in form, losses of oil are avoided, and the distribution of the lubricant which is produced is much more satisfactory than would be found with grooves cut by the older method. It will be seen from the illustration that the work is gripped in the chuck on the spindle of the machine and the grooving tool is held on the tool-holder on the slide. The capacity of the machine may be judged from the fact that it will swing over the saddle work up to 7 in. diameter and over the bed up to 15½ in., while the hole through the spindle is 3⅛ in. diameter. The headstock is cast solid with the bed, which is supported on a cabinet standard and leg frame. For cutting straight grooves the spindle may be looked in position, while it can be driven from the cone pulley through the gearing to obtain the three speeds of 12, 20 and 35 revolutions per minute for the production of spiral grooves. The necessary movement for the tool slide along the bed for the production of the desired grooves is obtained by the use of a slotted disc and crank. Variations of the stroke are obtained by setting the connection to the disc at different positions and a scale is provided along the slot in the disc for the purpose. To support long external work a simple loose tailstock is provided on the bed.

Screwing Machines.

Among their display of recent models of machine tools, Messrs. Kendall and Gent (1920), Limited, Victoria Works, Gorton, Manchester, show some examples of their designs of screwing machines for bolts and pipes, of which an example is illustrated in Fig. 201, annexed. This machine is capable of screwing bolts up to 2 in. diameter and pipes up to 4 in. diameter. The bed, which is a box-section casting with accurately-surfaced slides, forms a tank for the lubricant, while troughs at either side serve to collect and convey the lubricant to the tank. Rigid security to the bed is obtained for the headstock, which carries the spindle, gearing and the die box. The spindle is hollow and revolves in parallel bearings and has a wide range of speeds. An all-geared head with steel gears, which are put into action by the simple movement of hand levers without stopping the machine, is provided, but similar machines with cone pulleys and a gear drive may be obtained.

For the die-box a simple and compact construction has been adopted in which no use is made of springs nor are any of the wearing parts moved under pressure. The dies are carried in hardened-steel shoes which are held perfectly rigid when cutting and arranged so that they may be easily changed. With them the cutting action is tangential and gives ample clearance together with sufficient top rake, the whole arrangement being such as to make clean and rapid cutting possible. Automatic motion is provided for instantly closing and opening the dies. In addition to this automatic operation from the movement of the carriage, hand-lever actuation is also possible. The carriage, which is traversed along the bed by the hand operation of a pinion gearing with a rack, is provided with adjustable jaws fitted with hardened-steel shoes, forming a self-centring vice for gripping the work truly. Adjustment is possible in this for taking up wear. Similar machines are fitted with die-heads for using dies of the Landis chaser type. These have four cast-steel die holders which carry chasers having the profile of the thread on the face. The dies are arranged to open automatically with the movement of the carriage or by hand, and are held rigidly in holders which are pivoted on the face of the die-head. These have a fine adjustment for setting purposes. As the regrinding of the dies is done on the end and not at the throat, they may be ground until they become too short to be held in the holders, and consequently they have a long life. A fine adjustment is available to enable

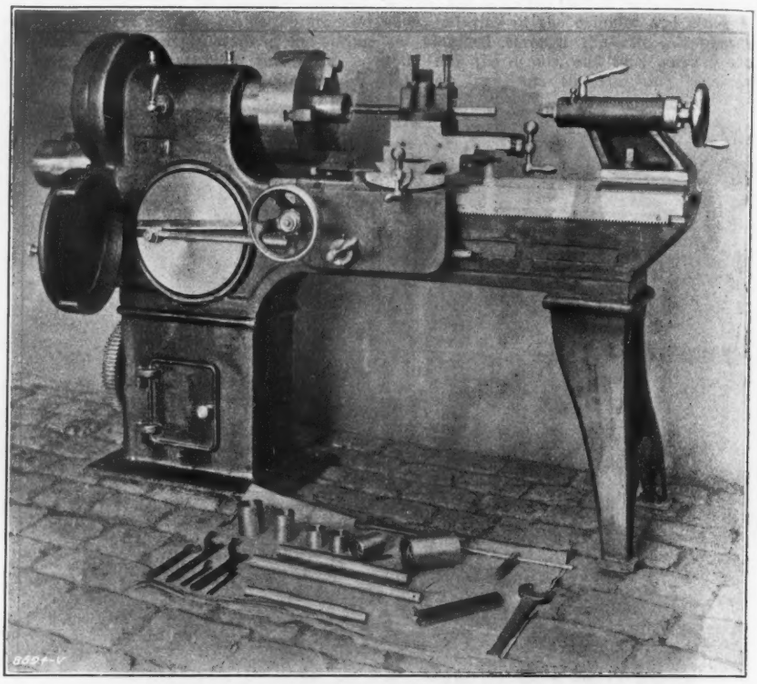


FIG. 200. OIL-GROOVING MACHINE; MESSRS. JOHN HOLROYD AND CO., LIMITED.

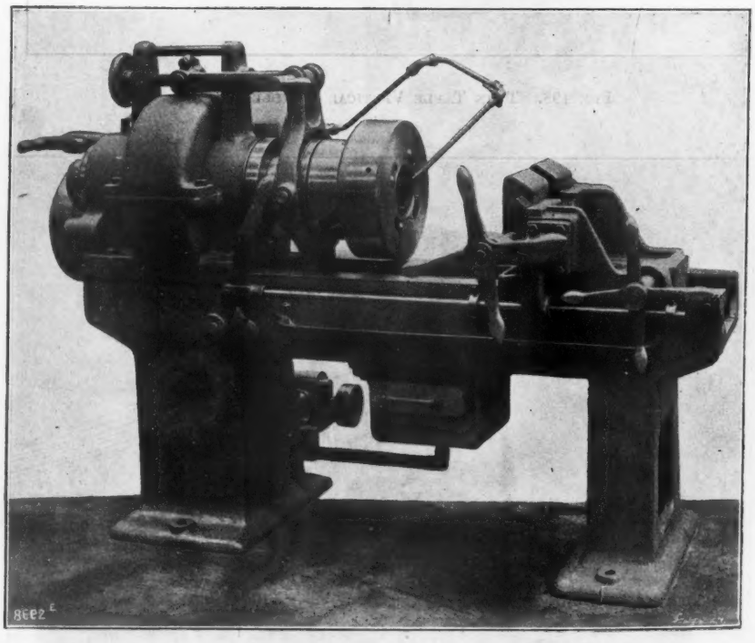


FIG. 201. BAR AND PIPE SCREWING MACHINE; MESSRS. KENDALL AND GENT (1920), LIMITED.

first and finishing cuts to be taken in the case of heavy or square threads.

TUBE-BENDING MACHINE.

A very serviceable workshop appliance, a tube-bending machine, which is exhibited by the New Fortuna Machine Company, Limited, of Southmead, Bristol, is illustrated in Fig. 202, below. In this machine the pipe is bent round a cast-iron former by the use of a mild-steel guide, each being shaped to suit the form and size of the tube. In the process use is made of a hand-operated worm engaging with a large worm-wheel rim surrounding the table. Twenty-two holes are provided in the table for the accommodation of stops for either right or left-hand bending. At the end of the worm shaft there is a double-thrust ball bearing. Pressing upon the back of the machined guide there is provided a phosphor-bronze roller in a slide mounted towards the end of a pointer lever. This has a centre pin at the middle of the table. Most tube-bending troubles are due to the variation of the point of application of the bending pressure. In this machine this point, which is governed by the position of the roller, is maintained in the correct position by means of a sliding pointer which is fitted to the lever. The bending point is obtained by setting the roller in any of a series of holes in the lever corresponding to the sizes of tubes to be dealt with, the machine being intended for bending to standard radii only, which is, of course, suitable for conduit or other cases in which radius is not an important consideration. Other machines exhibited by the firm are suitable for bending to any radius. Working with a standard radius or larger, the work may be accomplished in them, as in the standard machine, without any filling in the tube, but for small values loading with a mixture of equal parts of pitch and resin is recommended. With this method of working the bending of tubes may be done without the production of ripples in them. It is the use of centre pins which leads to this possibility of bending to small radii. In the smallest machines the pins are of $\frac{3}{8}$-in. diameter and make possible the bending of a tube $\frac{1}{2}$ in. in diameter to a $\frac{1}{2}$-in. radius. A $\frac{3}{4}$-in. pin replaces this in the second machine, with which a 1-in. pipe can be bent to a radius of 1 in., while one of $1\frac{1}{4}$ in. diameter for the largest machine makes possible the bending of a 2-in. diameter tube to 2 in. radius. It should be noted that the machine is suitable for use with tubes of brass, copper or steel, and for conduit or gas barrel.

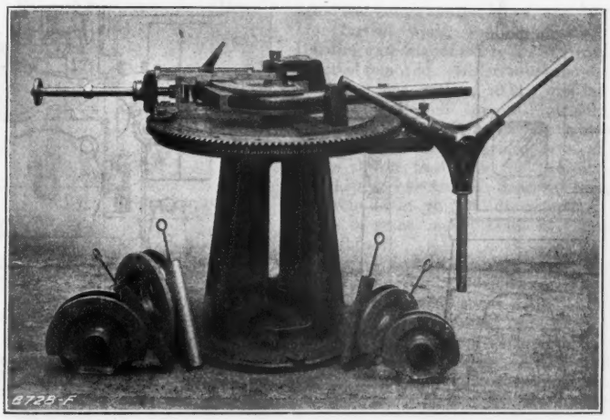


FIG. 202. TUBE BENDING MACHINE; THE NEW FORTUNA MACHINE COMPANY, LIMITED.

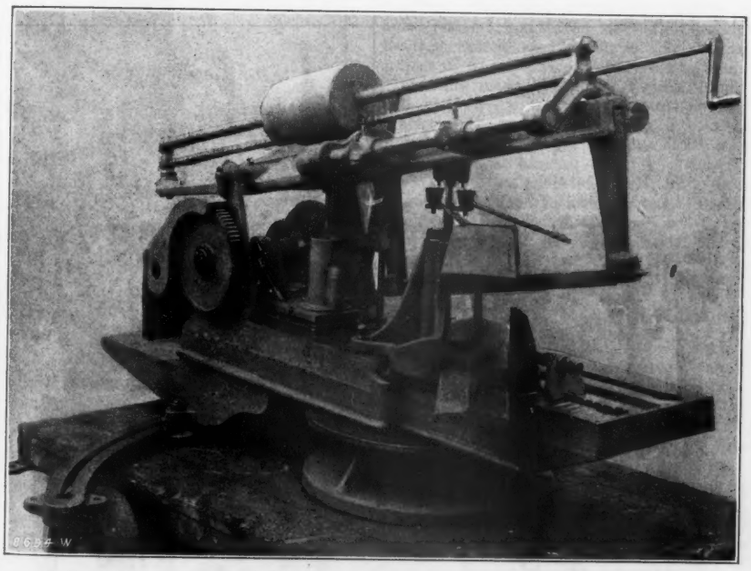


FIG. 203. MOTOR-DRIVEN SWIVELLING GIRDER SAW; MESSRS. CHARLES WICKSTEED AND CO. (1920), LIMITED.

HACK SAWS.

In a previous issue we illustrated some of the hack saws which are on view. Messrs. Charles Wicksteed and Co. (1920), Limited, of Kettering, are among the firms showing these tools. On a former occasion we illustrated Messrs. Wicksteed's "Merrythought" saw (vol. cx, page 341). The firm this year has a larger assortment of saws on view, one of the most interesting being that illustrated in Fig. 203. This is a motor-driven machine with a capacity for cutting girders up to 20 in. by 12 in. The idea on which it has been devised is evident from the illustration. The saw is mounted on a turntable, and the tail runs on a rail to which it can be clamped at any angle up to 45 deg. on either side of the straight, so that a cut can be made to any desired setting across the section. In this way long girders can be cut with the minimum of inconvenience in the shop, and angular cutting does not involve swinging the girder over the floor.

The saw is carried in a frame which reciprocates on two round slide bars of a hinged arm. This arm is carried by brackets at the back of the machine close to the crankshaft from which the reciprocating movement of the saw is derived. The crank is driven through gearing by a motor mounted on the tail of the swivelling bed. The arm has a heavy counterweight, the position of which can be adjusted by a quick-pitch screw and handle. The relief is given on the return stroke by means of an oil ram worked by an eccentric. This is a valveless device, the piston itself closing the port at the end of the cutting (draw) stroke. The arrangement acts as a dash pot, slowly letting the blade down on to the work at the beginning of the cutting stroke. The table is fitted with one tall swivelling bracket to take the pull of the cut on the draw stroke, the work being clamped hard up to this by means of a vice jaw with Taylor pattern dog, as may be seen in the illustration.

Another girder saw, but not of the swivelling pattern, is exhibited by Messrs. Wicksteed, as well as their boiler plate flange saw, a multiple saw, and other machines, both for general service and particular uses.

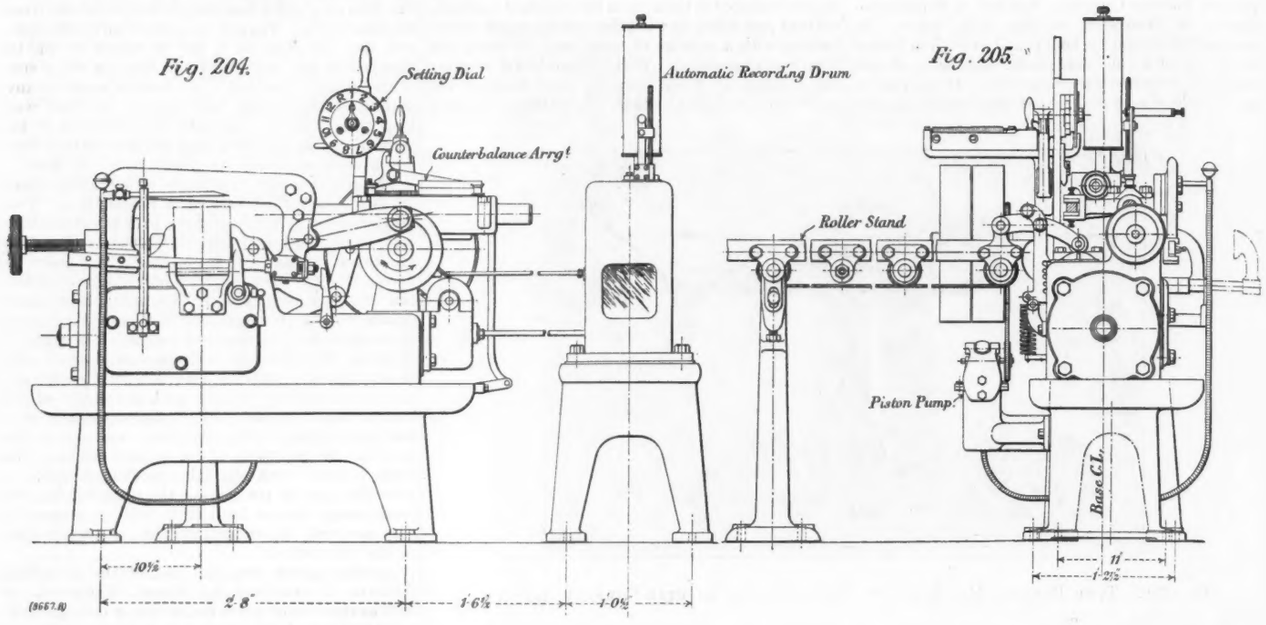
TESTING MACHINES.

To obtain the best results in the workshop it is necessary that whatever small cutting tools are used should have a long life and be suited to work at the highest possible speeds. Reasonable comparison of such tools can only be made under exactly similar conditions. For this reason Messrs. Edward G. Herbert, of Atlas Works, Levenshulme, Manchester, have introduced a saw blade testing machine, which may be used by the maker of blades to see that the standards of efficiency of their products are at all times maintained, and also by large users, for the purpose of comparing different makes and grades in regard to cutting properties. This machine is illustrated in Figs. 204 to 206 on page 446. It consists essentially of one of the makers "Automatic Rapid" saws with the addition of recording apparatus, by which information may be obtained on the number of cuts made and the number of strokes to complete a cut. The saw part of the machine may be used on actual work in the shop, whether tests are being made or not, and, as it is a good example of the best modern practice in saw construction, we may consider its design prior to showing how it has been adapted to the specific purpose of testing.

This saw was designed to deal with work on bars up to 6 in. by 6 in. section. It has an automatic feed and cutting-off mechanism. In design the outstanding characteristics are strength and rigidity. On the bed there are two square slides, for which the bearings are adjustable for wear and pivoted on an independent shaft with suitable bearings. The connecting rod ends are also adjustable for wear. The saw holders, which are rectangular in form, can be set to accommodate different lengths of blades and remain permanently in alignment. It will be observed that the saw blade is inclined to the horizontal, and this inclination continuously changes as the work proceeds, the whole arrangement being such that rapid cutting is obtained without the use of heavy weights. By the introduction of a simple oil dash-pot in conjunction with the angular setting of the saw and the changing speed of the crank, a positive lift is obtained for the saw frame during the return stroke. This lift may be readily changed by the simple expedient of turning a small spindle which controls the leak hole in the dash-pot piston. The mechanism for causing the lift of the blade at the conclusion of the work also serves to prevent the

HACK SAW TESTING MACHINE AT THE MACHINE TOOL EXHIBITION.

CONSTRUCTED BY MESSRS. EDWARD G. HERBERT, LIMITED, ENGINEERS, MANCHESTER.



saw frame falling should the saw blade break. An adjustable stop is provided by the use of which the work may be automatically stopped when the required depth of cut is made. For lubrication of the work a pump is provided to deal with the suds, and as it has an air chamber fitted on the supply side a steady supply is ensured. The automatic bar feed is set in operation by bringing a clutch into action, by means of which motion is given to a worm and wheel which drive a shaft passing through the machine, from which the chain drive to the rollers of the feed mechanism is obtained. The length gauge is seen at the front of the machine in Figs. 204 and 206 and in two positions, by full and dotted lines, in Fig. 205. Once this is set to the requirements and the bar is placed in the vice, when the setting dial is turned until the pointer indicates the number of pieces required or the letter R, denoting continued repetition, the machine may be started. No further attention is then required, and the machine will stop quite automatically when the work allotted to it is completed. When a cut has been made the saw frame rises, the vice opens and the piece cut off having fallen away, the stock is fed forward again to the length gauge. The operations that follow are the closing of the vice and the restart of the cutting operations.

The recording gear for use in testing is seen on the right in Figs. 204 and 206. Motion from the saw holder is taken to work a pawl which turns a toothed wheel, and this motion is used to raise the pencil. A vertical line is, therefore, drawn to represent the number of cutting strokes on the paper fixed to the drum and its height, measured on the scale provided, shows the exact number of strokes required for the complete operation. When the cut is completed the drum is turned about a quarter of an inch, the pencil falls, and the gear is reset for a new start quite automatically by a cam mechanism. It will be observed that tests may be performed with the machine on actual production in the workshop.

Another testing machine of service in dealing with questions of production in the workshop is the tool steel testing machine, which we illustrate in Fig. 207 on page 447. This is another product of Messrs. Edward G. Herbert, Limited, of Levenshulme, Manchester. By its use the cutting qualities of tool steels may be tested rapidly and inexpensively. The process is to measure the amount the tool steel will remove from a standard test-piece in the form of a long tube, while its cutting edge is worn by a definite amount. In the actual work the tool steel is shaped with a cutting edge of a standard form, and it is then gripped in position, with the revolving tube used as a standard resting upon it under a standard load. As the tool works against the end of the tube, the width of cut remains constant throughout all the investigations. For the revolution of the tube motion is obtained through gears from an inclined shaft, at the base of which there is a large friction disc resting upon a wheel, which may be given movement towards or away from the centre to obtain variations in speed. In addition to this, a gear box is provided in the drive to obtain large variations in the speed. With these two means of varying the speed, it is possible to obtain a continuous range of cutting speeds from 20 to 200 feet per minute. To observe accurately what the speed is in a test a pendulum of variable length is made to synchronise in its beats with the completion of each revolution. The length of pendulum used is the index to the actual speed, and a scale provided enables the deduction of the exact value instantly. An autographic record is made of the work done on a clockwork-controlled drum. When the fixed amount of wear of the tool

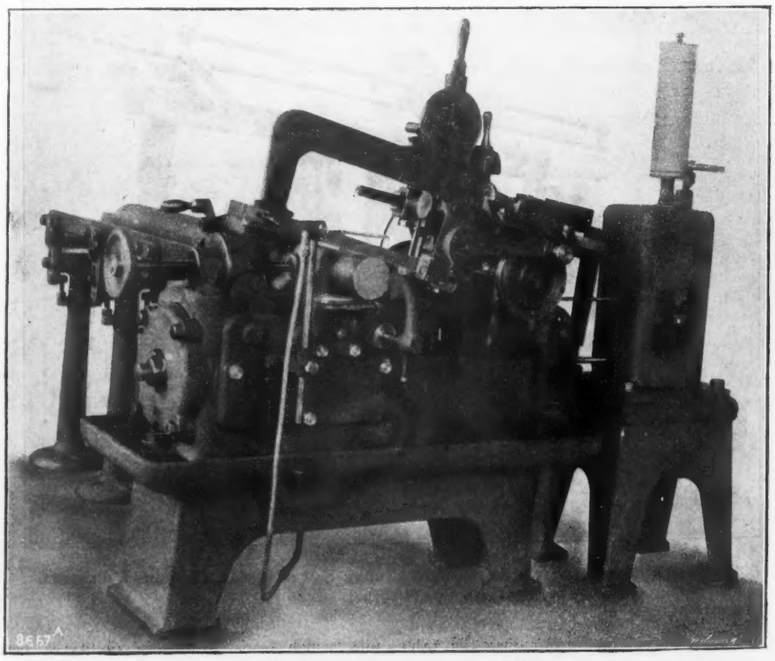


FIG. 206. GENERAL VIEW OF MACHINE.

has taken place contact is established by a small weighted lever, beside the tool, with the point of a micrometer screw, and a relay is thereby put into action and stops the recording apparatus. This testing machine has been put into service now by many governments in their ordnance factories, and by railway companies and large engineering concerns in their works, to obtain an

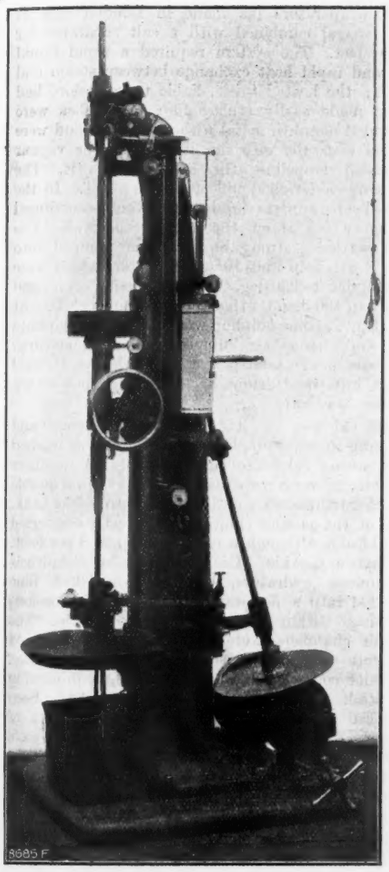


FIG. 207. TOOL STEEL TESTING MACHINE; MESSRS. EDWARD G. HERBERT, LIMITED.

index to the best working conditions for the steels they use, and to differentiate between the properties of the various classes of tool steels submitted to them.

TOOL STEELS.

Excellent displays are given at the Exhibition by some of the tool-steel manufacturers of tools made in the standard materials they produce. Messrs. Thomas Firth and Sons, Limited, of Norfolk Works, Sheffield, for example, show high-speed twist drills made of "Speedicut," and for purposes of demonstration of the work that can be done with them a 36-in. vertical-spindle drilling machine made by Messrs. William Asquith (1920), Limited, of Halifax, is installed on the stand. The machine is used to demonstrate the drilling of 3-in. thick billets of 0·30 per cent. carbon steel. For this work penetrations at a rate of 9 in. per minute are made with a drill of 1 in. diameter, at 5¾ in. per minute with the 1½-in. size and at 4½ in. per minute with a 2-in. drill. When it is recognised that these rates can be maintained consistently the properties of the tool steel used may be appreciated. It must, of course, be understood that the maximum rates of penetration are in excess of these demonstration values. Milling cutters, reamers, centre drills, and other tools of their manufacture are also displayed by Messrs. Thomas Firth and Sons, Limited. A file-testing machine is shown in operation to show the performance obtained with the firm's files. It is rather unfortunate that files have frequently been purchased solely on considerations of first cost and with little attention being paid to their properties as cutting tools. Only by actual demonstrations can the significance of production be brought home to users, and therefore testing machines must play a large part in this propaganda work. In the tests a 14-in. hand bastard file is shown at work on a test bar of 1 in. square, which has a composition of 1 per cent. carbon, 0·30 per cent. manganese, and 0·06 per cent. silicon. With a standard pressure on the file of 30 lb., when working at 54 strokes per minute, 48·5 cub. in. were removed in a demonstration test before the file, which was still in a condition for further work, was withdrawn. The average cutting rate amounted to 3,220 strokes per cub. in. of steel removed. Other tests show the work that can be done with a 10-in. mill-saw, second-cut, single-cut file on saw-steel strip hardened and tempered to 550 Brinell. The tool in question is one designed for sharpening saws, and actual tests have shown that this file can attack hardened steel quite effectively. Inserted tooth metal saws of from 18 in. to 5 ft. diameter and woodworking tools of great variety made in "silver steel" are also shown.

Messrs. Samuel Osborn and Co., Limited, of Clyde Steel Works, Sheffield, demonstrate the use of their high-speed steels with the use of a 12½-in. centre sliding, surfacing and screw-cutting lathe supplied by Messrs. John Lang and Sons, Ltd., of Johnstone, and a 36-in. vertical drilling machine made by Messrs. William Asquith (1920), Limited, of Halifax. Tools of three qualities of steel—"Mushet," "Double Mushet," and "Triple Mushet"—are shown in use with the lathe, while twist drills made from the first two classes in two different tempers are in use in the Asquith drilling machine. Other tools displayed are milling cutters, hobs, reamers, and slitting saws of all descriptions. Rustless iron is also shown, as well as many examples of work to which it has been applied.

Broaches made by Messrs. Vickers Limited, as well as four-jaw chucks and quick-change drill chucks of the same manufacture, are among the many small tools exhibited on one of the stands of Messrs. Charles Churchill and Co., Limited. Demonstrations are made with "Hydra" tool steels by Messrs. Hall and Pickles, Limited, of Port Street, Manchester, as well as of bright cold-rolled steel bars in automatic machines, for which work they are particularly suited because of their continuous uniformity of physical characteristics.

SMALL MACHINE TOOLS.

Small machine tools, although their general lines are standardised, are always of great interest, and attention should, therefore, be called to the stands of Messrs. Henry Milnes, the Britannia Lathe and Oil Engine Company, Limited, and Messrs. Drummond Brothers Limited. Messrs. Henry Milnes of Ingleby Lathe Works, Bradford, show on their stand a 4½-in. centre lathe of the self-acting sliding, surfacing and screw-cutting type, which has its crankshaft mounted in ball bearings. This tool has a quick withdraw motion for the slide rest and has provision for driving milling attachments. A new model of a double geared self-acting sliding and screw-cutting lathe of 3¾ in. centres is also shown. This has a hollow spindle revolving in roller bearings and also the new type of apron introduced by the firm. As shown at the exhibition this machine is fitted with a division plate and spring stop as well as overhead equipment for driving gear-cutting attachments. A small planing machine is also shown which is suitable to deal with work 24 in. long, 12 in. wide and 10 in. deep, and has an automatic feed to the horizontal cut.

The Britannia Lathe and Oil Engine Company, Limited, of Colchester, show amongst other machines a new design of small screw-cutting lathe. This has 4¼ in. height of centres. The treadle motion is entirely contained in the legs. The flywheel is of greater dimensions and weight than is common and its shaft runs in ball bearings. The saddle is accurately fitted to the bed and is provided with a boring carriage, having a number of T-slots for holding down work for boring or milling. A great range of this work can be performed with the machine through the use of its cross traverse motion. A tailstock of the solid pattern is provided which is graduated and arranged to set over for taper turning.

Messrs. Drummond Brothers, Limited, of Rideshill, Guildford, in addition to their tool room and other types of lathes show machines of 3½ and 4 in. centres which are suitable for model makers. These machines are standard products, many of which we have already referred to in our columns. Their characteristics and the quality of work produced with them are now well known. The new model of the 3½ in. centre lathe has a cantilever bed, a hollow mandrel and ball thrusts for the spindle. There is a rack traverse for the saddle and the toolholder has a height adjustment. A milling attachment is provided and the machine is driven by a treadle system making use of ball bearings.

CONTROL PANELS FOR MACHINE TOOLS.

In recent years a great increase has taken place in the individual driving of machine tools by electric motors. For the purpose control panels have been designed in order that operation may be reduced to the most simple movements, and yet with every assurance that the electrical equipment shall suffer no injury through faulty manipulation. In this development three firms which have played a part, the Igranic Electric Company, Limited, of 147, Queen Victoria-street, London; Brookhirst Switchgear, Limited, of Northgate Works, Chester; and The Electrical Apparatus Co., Ltd., of Vauxhall Works, South Lambeth-road, London, have stands on which their panels are shown, but in addition their use, as fitted to the driving of individual tools, may be seen on many stands. For radial drills, shaping and slotting machines, the Igranic Electric Company, Limited, supply their "Varispede" pillar panel which has a split constructon for the housing, and therefore gives great ease of access. In this panel too rapid starting is made impossible by the use of an overload device which causes the circuit breaker to open. Once this happens, the breaker will only reclose, after bringing the starter handle back to its initial position again. The same action takes place if an attempt is made to start the motor against an injurious overload. Inching is made quite harmless by an arc-preventing interlock. Since there is but one starting handle, and only one movement of it is possible, operating in wrong sequence is totally impossible. Stopping may be attempted by a thoughtless operator by moving the starting handle back, but this causes no trouble, for the arc-preventing interlock causes the breaker to open on the slightest backward movement of the handle. An automatic universal panel for variable speed motors is also shown by the Igranic Electric Company, Limited, which is suitable for controlling such machines as lathes, boring and milling machines and especially where provision must be made for inching. This panel may be operated by push buttons or other master switches, placed in convenient positions on the machine. Drum controllers for cranes, and starters tor alternating current machines, also constitute features in a full and attractive display of electric control equipment.

Brookhirst Switchgear, Limited, also show types of panels for electric control of motors for various services, mainly in actual use on machines throughout the exhibition. The "Midget" type panels suitable for small sizes ot motors, are of the face plate type, have a no-volt release and overload trip and two fuses. A quick break operated main switch is provided, and this is in a separate sealed chamber, and is so interlocked that it must be in the "off" position before the door can be opened. There can be no doubt that this panel constitutes a satisfactory solution for the requirements when the motor power is small and, consequently, little may be spent on control gear. For the Brookhirst solenoid type of automatic starting panel a 3-push button (start, inch and stop) is used. This may be placed in any convenient position on the machine beside the operator, while the panel itself may be located in any available position. In this equipment an instantaneous full-faced butt-contact on each step is obtained and, consequently, the sparking troubles, sometimes associated with sliding contacts, are eliminated. An eddy-current retarder in series

with the armature of the motor is used to govern the starting movement. Many other varieties of panels are to be seen among the 50 to 60 which control machine tools throughout the exhibition.

The Electrical Apparatus Company, Limited, demonstrate the use of the great variety of switch and control gears which they manufacture, among which are not only to be seen pillars with no-load and overload releases, automatic contactor starters, and oil immersed reversing controllers for heavy duty, but also many details of considerable convenience and significance in providing for safety. The universal sealing boxes for armoured cables, which they show, overcome the difficulties which are encountered when cables do not approach the plant in a direction suited to the use of a fixed entrance cone. These sealing boxes can be instantly adjusted without the use of tools, so that the cable can be taken in at any angle and they therefore serve a very useful purpose where space is limited.

THE BRITISH ASSOCIATION MEETING AT TORONTO.

(*Continued from page* 411.)

SECTION B.—CHEMISTRY.

The chief problems discussed by the chemists were State aid to chemistry, Canadian electro-chemical and fuel industries, and colloids. The discussions on these industries were followed by visits to works, during and after the meeting. The Section, in fact, resolved to regard the informal meetings and visits to works made in connection with the western excursion as part of the sectional proceedings. With respect to the Canadian industrial problems, we might refer our readers to our comments on the proceedings of the World's Power Conference, especially on the transactions of the Sections on electro-chemistry, steam power production, gas and fuel and fuel preparation.* That the speakers were not the same in the two places imparts additional value to the proceedings at Toronto, which were highly interesting throughout.

The sectional officers were: President, Sir Robert Robertson, F.R.S., principal of the Government Laboratory, London; Recorder, Professor C. H. Desch, F.R.S.; Secretaries, Dr. E. K. Rideal, Cambridge, and Professor Ardagh, Toronto.

Chemistry and the State.

In his presidential address, Sir Robert Robertson sketched the historical development of the main chemical activities of the State, reviewing the conditions in Great Britain, having regard also to the Dominions. He dealt in his chief sections with defence, explosives and chemical warfare, with metallurgy, revenue, health, agriculture, and with organised applied research and assisted general research. Gunpowder and guns, he mentioned in the course of his address, were brought over to England by a Fleming, John Crab, in 1314. Faraday was a lecturer at the Royal Military Academy, Woolwich, 1829 to 1853; his assistant was James Marsh, the discoverer of the arsenic test; his successor was Frederick Abel, who, assisted by Kellner and Deering, and later also by Dewar and Dupré, pulped guncotton and invented cordite in 1890. The Royal Gunpowder Factory became a model of an explosive factory; gunnery research was conducted at Woolwich. The puddled steel of the early days was rejected as not uniform by the Admiralty and Board of Trade; converter steel also lacked uniformity, but the Siemens open-hearth steel was approved by the Director of Naval Construction in 1879.

"Mynteres" were appointed by King Athelstan, in 928; "moneyers," supervisors of the coin, in 1180. As regards revenue and alcoholic beverages, the mixing of wines with cider, herbs and vitriol was forbidden in the reign of Charles II; the assessment of "single and double proof spirit" dates from William III. At present the Government Laboratory was concerned with alcohol, tobacco, sugar, tea and cocoa, dyestuffs (since 1920), and substances under the Safeguarding of Industry Act of 1921. Coffee came only under the Adulteration of Coffee Act (1718), a Tea Act followed in 1730, and there had been various Food Adulteration Acts since 1855; in 1875 the Inland Revenue Laboratory (now the Government Laboratory) was made the authority to which Courts of Law referred disputed cases. But there was nothing in the United Kingdom corresponding with the series of food definitions and standards existing in some of the Dominions and notably in the United States.

Sir Robert referred briefly to water supply, sewage and atmospheric pollution, and factory and alkali works inspection. He had more to say on agriculture and research during and after the war. The number of chemists working in departments maintained wholly by the State was 375 at present, against 150 in 1912, whilst in State-supported establishments the corresponding numbers were 150 and 50; the grants made to 145 research students and 11 independent workers involved a yearly sum of 50,000*l*. The State, he said in concluding, had been compelled to give heed to chemical matters involved in its defence, as it had to maintain a currency standard and to secure a revenue. Those activities, conducted mostly with inadequate staffs, had proved to be of national advantage. The last stage was the recognition that the State was under an obligation to assist science and the science of chemistry, on which so many industries were based.

The Activation of Nitrogen.

Professor W. A. N. Bone, F.R.S., described the results of recent bomb experiments made by himself* and Messrs. Newitt and F. A. Townsend upon "the Activation of Nitrogen in the Explosions of Carbon Monoxide-Air Mixtures at High Initial Pressures" up to 100 atmospheres. A peculiar exothermic effect, he explained, accompanied by a formation of nitric oxide, NO_2, was observed in some cases, but only in the presence of both nitrogen, N_2, and carbon monoxide, CO (not, for instance, in hydrogen-air mixtures). Now these two gases had the same density, and Professor Bone suggested that the radiation emitted by one of them burning in the other set up a resonance vibration and "activated" the nitrogen, which was then able to combine more readily with oxygen than it would be at correspondingly high temperatures in other gas mixtures. A similar effect had been observed by F. Häusser, who attributed it to some ultra-violet radiation. Professor Bone is continuing these researches, which, he added during the discussion, did not so far promise an improvement of technical nitrogen-fixation.

Canadian Electro-chemical Industries.

The discussion of this subject was opened by Mr. D. A. Pritchard's paper on "the Canadian Salt Company's Processes for the Manufacture of Alkali-Chlorine Products." In the vast salt deposits of Ontario and Michigan, he stated, the salt layer, 230 ft. thick, was stratified with shale and dolomite. Their Windsor works (of which he is manager), started in 1912, received 4,000 h.p. from the Niagara Power station, 270 miles distant, at 110,000 volts alternating current, transformed down to 250 volts direct current, and also had a steam plant of 3,000 h.p. The brine was saturated at 85 deg. C. and mixed with soda and a trace of caustic to precipitate magnesium and calcium salts; the soda was made by passing boiler-flue gas through the caustic. The closed cells for the electrolysis of the brine were of the type which Mr. A. E. Gibbs (an Englishman) introduced at the Pennsylvania Manufacturing Company in 1917, and modified only as regards circulation. The iron cylinders, 37 in. high, 25 in. diameter, contained a cylindrical cathode of perforated iron, 22 in. diameter, covered on the inside by the diaphragm, and close to it were 24 vertical graphite rods 2 in. by 2 in. by 36 in., suspended from a dome (made by the firm, like the diaphragms, the latter being of asbestos and cement). The cells, 35 in series, took 3·57 volts each at 1,000 amperes. The cell was kept full of brine; the chlorine escaped through pipes at the top into a main kept under slight suction, and the hydrogen was similarly taken from the outside of the cathodes to a smaller main. The caustic trickled down into tanks. The current efficiency was 90 per cent. to 95 per cent., the power efficiency 57 per cent., and the process yielded 5 lb. of caustic (120 grammes per litre) and 4·43 lb. of chlorine (of 95 per cent.) per square foot of floor space per 24 hours.

The lye was concentrated in two Scott double-effect evaporators (as made in London and at Fall Rivers) combined with a salt separator for each effect. The system required a rapid liquid flow and rapid heat exchange between steam and liquid; the heated tubes, liable to corrosion, had to be made easily replaceable; the tubes were expanded metal to metal without gaskets and were carried vertically into the evaporator, the vapour generated propelling the liquid before it. The company preferred double to triple effect. In the conical separator the liquid was given a centrifugal motion which threw the salt to the wall. The clear settled "strong liquor" was pumped into pots, 7 ft. deep and 10 ft. diameter, which were heated, first to 250 deg. C., when foaming set in, and finally to 500 deg. C., the lye being replenished. At 450 deg. C. some sulphur was added to precipitate iron and manganese compounds; after settling, the caustic was poured by means of a centrifugal pump into steel drums or trays, each pot giving 16 tons of caustic.

The chlorine was taken through a cooler and a drying tower, 40 ft. high, in which it was washed with strong sulphuric acid, to the iron liquifiers at 50 lb. pressure per square inch, rising in a double coil at a temperature of 25 deg. C. into a steel tank. Part of the gaseous chlorine was directly converted into bleach, although it contained up to 5 per cent. of carbon dioxide. Use was made of Schultheis continuous hydrators, in which unslaked lime was fed into a perforated cylinder (stone basket) rotating within a steam-jacketed drum. The bleach chambers were made either of tar-lined concrete provided with double asphalt floors, in which cooling coils were embedded, or preferably of lead. Recently these chambers had been replaced by the mechanical bleach chambers of Messrs. Rudge, of Gateshead-on-Tyne, which gave a more uniform bleach of higher strength and avoided the disagreeable packing of the chamber.

Commenting on this unusually instructive paper, Sir Max Muspratt said that the United Alkali Company had decided to adopt the Gibbs process just before the war, but their expert had gone down with the Lusitania; Mr. Pritchard had himself then stepped in and built their new works without a hitch. The Castner-Kellner mercury cells were good, but more expensive than the Gibbs cells, which had also proved slightly more economical in working at Widnes and at Detroit. Sir Max added that his own company transformed chlorine into hydrochloric acid, but chlorine was the best disinfectant and capable of unlimited applications. Emphasising this statement, Professor Donnan, F.R.S. (one of the vice-presidents), referred to chlorine and sodium as possible fuels of the future.

Discussing "Electrolytic Nickel Processes" in the next paper, Mr. R. L. Peek, of Dechenes Mills, Quebec, said that the nickel-copper matte, concentrated in converters, contained 80 to 87 per cent. of these metals, sulphur and small amounts of iron and platinum. The nickel was mostly recovered by the sodium sulphide process or the carbonyl process and could not be, in the latter case, improved electrolytically. He would discuss the two chief electrolytic processes actually applied. David Browne had, in 1902, reduced the roasted matte by charcoal, cast part of it as anodes for the copper separation step, and granulated the rest by pouring it into water. The granules were dissolved in chlorine and salt solution and electrolysed for copper until the bath contained only 1 gramme of copper per litre; this copper was precipitated by sodium sulphide, the iron was oxidised and precipitated by caustic potash, and the nickelous chloride electrolysed with graphite anodes and nickel starting sheets. Working with a current density of 20 to 40 amperes per square foot at 60 deg. C., a pure nickel was obtained;

* See Engineering, July 11, 18, 25, on pages 37, 78, 81, 116 *ante*.

* *Vide* Engineering, May 18, 1923, page 625.

CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT.

FIG. 31. EXCAVATION OF POWER HOUSE SITE; LOOKING ACROSS DOCK.

but Browne was not able to overcome all difficulties. In the second, Hybinette process the roasted matte was leached with sulphuric acid to remove some copper, and the residue was smelted down with coal and cast into anodes, which, though containing copper, deposited almost pure nickel from the sulphate bath. This was attained by suspending the cathodes of nickel in canvas bags and feeding nickel sulphate solution (a product of the further process) in at the top of the cathode at such a rate that the copper ions were prevented from entering the bag through the holes in the canvas. That was possible, but not when rents developed in the bag or the holes became clogged with colloidal nickel. The anolyte was then freed of its copper by treatment with anode scrap, or by passing it over granulated Bessemer matte, or in other ways which Mr. Peek suggested.

On behalf of Mr. F. A. J. Fitzgerald, of Niagara Falls, Mr. J. Kelleher then gave an account of the developments of Fitzgerald's "Resistor Furnaces," first installed by the latter in the Hohenlohehütte, Upper Silesia, for smelting zinc blende by a modified Imbert process in which a bath of fused iron acted as solvent for the blende. An arch of carbon rods, arranged transversely, was first used. Later, corrugated slabs of carborundum were pressed together with a temporary binder and then recrystallised in a carborundum furnace, to form a resistor arch; two such arches were arranged longitudinally, sometimes in a closed chamber above the hearth in order to exclude the air. Spirally-cut carbon resistors and other shapes were also used. These furnaces served for various purposes, for the distillation of zinc and for the preparation of zinc oxide (required in the rubber industry) by burning zinc vapour in the air. It was fortunate that the zinc vapour column issuing from the furnace did not catch fire immediately; otherwise the orifice would become clogged. The carborundum bricks were, after 30 days' service, found fused to a depth of 4⅛ in. Mr. Kelleher also illustrated by various slides the transformers required for working the large resistor furnaces.

The next paper was by Mr. Horace Freeman, of Shawinigan Falls, on "The Economic Aspects of the Hydrometallurgical Development in Relation to Canadian Natural Resources." Mr. Freeman stated that Trail (British Columbia) produced 20 per cent. of the world's electrolytic zinc and most of its electrolytic lead (both by the fluosilicate process), in addition to precious metals. The Niagara districts produced nitrate, alkalis, chlorine, graphite, carborundum and also cyanide, which was now utilised for fruit fumigation. The Sudbury district supplied 60 per cent. of the world's nickel, but was overproducing at present; important developments were now taking place in the Cobalt and Porcupine mines farther north. The Shawinigan Company on the St. Maurice River and other plants on the Saguenay River, had developed half a million horsepower for the production of carbide, carborundum, aluminium and acetic acid. All these companies were competing in the world's market, but some of them had to import their raw materials. It was a serious question whether Canada should be allowed to export power to the United States, as had been proposed. On the other hand, water should not be permitted to flow unharnessed. Canada was leading in power resources and in ores. Many of these ores were sulphides; the flotation process had made it possible to concentrate them on the spot and to ship the concentrates to the power stations. But very little was known about the metallurgical chemistry of sulphides and their genesis. The "plastic magma" theory of the geologists* was, however, largely accepted now, and under the auspices of the Research Council of Canada he was investigating the nature of solutions or magmas from which the ores had separated and which moreover, might be suitable as baths for electrolysis, a very important matter. He had already worked out an electric furnace process for the preparation of sodium sulphide in this connection.

Mr. F. A. Lidbury, of the Oldbury Electrochemical Company, drew attention to another utilisation of hydro-electric power in his paper on the "Characteristics of Electric Steam Generation." One kilowatt-hour being roughly equivalent to the heat produced by the combustion of ¼ lb. of coal, he said, the electric steam boiler could not, in spite of its efficiency of 95 per cent., compete with the coal-heated boiler, except in special cases and when even a temporary surplus of hydro-electric power was available. Then, however, it was extremely useful, even at varying capacity. The price obtained for electric steam supply in Canadian paper pulp mills was very low, but it was a return where otherwise there would be none. The electric boiler was very cheap; but the power mains and the pipe system might cost many times more than the boiler, and the boiler should be erected close to the existing generators and to the steam pipes.

As to the type of boiler, Mr. Lidbury referred to the excellent apparatus of Mr. F. T. Kaelin, of Shawinigan, who used alternating currents of 110 volts to 12,000 volts, on single or triphase circuits, in the latter case with three electrodes in one vessel or one electrode in each of three vessels, vertical steel cylinders provided with an inner shell of steel (like a jacket) to prevent destruction of the outer shell by arcing. The electrodes were vertical rods suspended from above, the boiler being a wet rheostat. The load was controlled by automatic adjustment of the water level or of the depth to which the electrodes penetrated into the water. As, however, the salts in the water concentrated and increased its conductivity, a "bleeding valve" for drawing off the water was attached to the bottom of the boiler; the water feed was also from below, first through the water jacket. Exact efficiency calculations were difficult because there was hardly any data on the conductivity of hot salt solutions. For storage purposes large boilers were used and were provided with stirrers to diminish the temperature difference between the top and bottom.

The papers left little time for a general discussion. The visit to the electro-chemical plants of the Niagara district took up the Friday afternoon and Saturday.

(To be continued.)

* This question was discussed in the Geological Section by Professors M. B. Baker, A. P. Coleman, and others. The sulphides of Sudbury occur together with norite, the granitoid equivalent of basalt. The "magmatic differentiation" theory suggests that the sulphides separate from the cooling, still plastic magma, which is really a solution, as was first taught by Bunsen.

THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, B.C.

THE harbour of Esquimalt, immediately adjacent to Victoria on its western side, at the southern extremity of Vancouver Island, B.C., was formerly well known as the North Pacific Naval Station, directly under the Admiralty, but is now under the Canadian Department of National Defence. The harbour is an excellent one and well sheltered, and as long ago as 1887 a graving dock was built there by the Canadian Government. The dock had a depth over sill of 26½ ft. at high tide, a usable length of 430 ft., and a width of 65 ft. at the entrance. Its position is indicated in Figs. 1 and 2, Plate L, on the southern side of Constance Cove, facing nearly due north. This dock has been in constant use, but the need has been felt for something better able to cope with naval and merchant vessels of modern size, and, in order to provide adequate docking and repairing facilities, the Federal Government decided in 1920 to construct a new dry dock of enlarged size. The site selected for this was at Skinner's Cove, on the north side of Constance Cove, the lay-out being approximately east and west. The work is in the charge of the Department of Public Works of Canada, by the courtesy of which we are enabled to give, in Figs. 1 to 33 on Plate L and on this page and page 454, drawings and views which show the main features of the undertaking. The dock will accommodate the largest class of ships, a depth over sill at high tide of 40 ft. being provided, while the maximum usable length will be 1,150 ft., this being identical with the large dock recently opened at St. John, New Brunswick. The width at the entrance at coping level is to be 135 ft., while the horizontal width on the entrance sill level will be 107 ft. 1¾ in. At coping level the dock chamber is designed for a width of 149 ft., this level being 14·5 ft. above low water. At floor level, 34·5 ft. below low-tide level, the width will be 126 ft. To the west of the dock there is a landing wharf 800 ft. long.

A plan of the site with contour lines is given in Fig. 3, from which it will be seen that practically the whole of the area has to be excavated from low-water level downwards. At the extreme outward end the bottom fell away on one side, but more than half the section had to be cleared. Rock was found at a convenient depth over the whole floor, and the inner, or north, side of the dock will consist of wall facing built against solid rock. The outer, or southern, wall is of gravity section extending in some parts to floor level, but in others

finishing on rock dressed off at a higher level. Thus at the stations marked in Fig. 3, 3 + 00 to 7 + 00, the rock under the outside wall is finished at a higher level than the floor. At stations 2 + 00, 8 + 00 and 9 + 00, the gravity section extends for the full depth. At station 10 + 00, which is exceptional, there is a hollow in the rock whose surface here is much below floor level, involving a considerable amount of filling with mass concrete, a gravity section completing the wall at this point. At stations 11 + 00 to 13 + 00 rock extends to within a few feet of copying level on both sides, and the excavation needs lining only. The landing wharf is situated also on rock which is dressed to 33 ft. below low-water spring tides.

A plan of the lock is given in Fig. 4, while in Figs. 5 to 8 are given four cross-sections at points indicated on Fig. 4. At the entrance of the lock are two caisson stops, and the chamber is divided into three lengths of 400 ft., 350 ft., and 400 ft. by further caisson stops, as shown in Figs. 3 and 4. The cross-section, Fig. 5, is taken at the outermost caisson sill. The design is identical in the four cases. The small section inset in Fig. 5, shows details of the sill and caisson berth. The width of the sill is 8 ft. Fig. 6 shows a normal cross-section of the chamber with a bottom width of 126 ft. and three altars at + 10½, — 6, and — 12 elevation. The walls and floor are of mass concrete of 1 : 3 : 5 mixture. For the inner face, for a depth of 12 in., a 1 : 2 : 4 mixture is used. The altars and coping will be faced with block granite 12 in. thick. The caisson sills are also to be finished with dressed granite, while one 10 ft. and two 9-ft. widths of granite blocks run the whole length of the chamber for the keel and bilge blocks. The chamber walls have a batter on the inside of 1 in 15 from the floor to the lowest altar. Above this the walls are vertical. On the outside the gravity-section parts of the walls have a batter of 1 in 10. On the sea side the concrete work is backed by 6 ft. of clay puddle, beyond which is filling carrying a 50-ft. roadway.

Fig. 4 indicates the site of the power-house, placed about midway along the dock side. It is connected with a single filling and emptying tunnel 7 ft. wide and 12 ft. high, fitted with two valves and terminating in the landing-wharf structure, or north-wing wall at the dock entrance. The main pumping plant is to consist of three 42-in. centrifugal pumps direct-connected to vertical-shaft induction motors of 1,000 h.p. Each of the three sections of the chamber is provided with filling and emptying culverts 5 ft. wide and 6 ft. high. These form endless loops under the floor of each part, each loop being provided with an additional cross-culvert at the centre of its length. Water is admitted to the culverts, or to the chamber from them, through gratings in the floor over the lengthwise portions. These openings are 2 ft. 6 in. square and are spaced 10 ft. apart. The filling and emptying culverts are shown in Figs. 6, 7 and 8, and in the plan Fig. 4. Fig. 7, a section taken across the middle of the central section, shows the cross-culvert and the sump and main culvert for this section of the dock, leading to the pumps. Any combination of pumps will be available for any section of the dock.

Tunnels for pipes and conduits 4 ft. wide and 6 ft. 6 in. high are arranged in the side walls, the crown level being 2 ft. 6 in. below the coping. At a height 2 ft. 6 in. above floor level a horizontal recess 1 ft. 6 in. high runs along the walls for the accommodation of air and water pipes. Arrangements are made for the relief of any tendency for upward hydrostatic pressure to develop, by means of tile drains under the concrete floor and behind the walls, with 1½-in. zinc relieving pipes extending through the concrete structure. Special provision is being made for sanitary arrangements for ships docked and for workmen. In the floor of each section of the chamber 8-in. cast-iron sewers are being laid, with manhole connections to which it will be possible to attach hose from the ship's ports. The manhole covers can also be lifted and portable latrines placed over them for use by the workmen. The sewers connect with a separate sump from which the sewage is handled by a 6-in. pump. The pump-house installation will further include a fire pump and exhauster pump. The building is arranged far enough from the dock side to allow for a roadway and permit of the passage of cranes and other traffic in front of it.

At each end of the dock are two stair wells, in the side walls. The stairs are arranged in three flights. At the inner end these stairs are arranged as shown in Figs. 9 and 10, at the same point timber slides being provided. These are 4 ft. wide and are sloped at about 45 degrees, easing off to the horizontal by means of a curve at the lower end. The slide is faced with granite blocks 14 in. thick with a 4-in. lip, 6 in. wide on the outside. Altar ladders are arranged to the number of six sets to each side of the dock chamber. Details of these are given in Fig. 11 as regards the altar ladders, and Figs. 12, 13, and 14 as regards the lowest unit extending to floor level. At each ladder, each altar and at coping level, cast-iron hold-fasts are let into the granite blocks, as shown in Figs. 11, 12, and 13. Details of these are given in Figs. 15 and 16. They are placed 18 in. back from the edge, the slots being 9 in. long and 1½ in. wide, undercut to afford good hold for boat-hooks, &c., and drained below by a 1½-in. hole. The keel blocks are shown in Figs. 17 to 26. They consist of three castings, an upper and lower casting with a wedge between, the fitting faces being planed with an overlap, as shown in Figs. 23 to 26. The upper casting is faced with an oak block 4 ft. 4 in. long, 1 ft. wide, and 9 in. deep. The block is dovetailed into the casting.

Eight capstans will be provided on the dock sides and one at the end of the chamber. The former will have a full-load capacity of 25,000 lb. at 12 ft. per minute, and the latter a capacity of 65,000 lb. at the same speed.

The landing wharf, which extends (Fig. 4) for 800 ft. from the caisson berth at the dock entrance, is of composite timber and concrete construction, resting on rock. This wharf is built up of units of 100-ft. length, as illustrated in Figs. 28 to 30. This form of construction is not uncommon on the Pacific Coast. Each section consists of a timber crib, built up of 12 in. by 12 in. timbers, as shown. The principal members are 8 ft. cr. to cr. longitudinally and 9 ft. cr. to cr. across the crib. The bottom is floored with timbers measuring 16 in. by 16 in. The deck is laid with 6 in. by 12 in. planking, the cross-bearers being doubled at this level and spaced, therefore, only 4 ft. cr. to cr. The crib sides are encased in concrete, which on the rear and end faces is plain and 1 ft. thick, and on the front face 2 ft. thick reinforced with ¾-in. loop rods, as shown in Fig. 27, spaced 2 ft. apart as regards height. The end wall of the whole structure is similar in thickness and reinforcement to the front face. The reinforcement and concrete are secured to the cribbing by means of hooks and eyes—both at frequent intervals. The proportions for the facing concrete are 1 : 2 : 4. The cribs are filled with stone. The crib coping level is 3 ft. above low-water spring tides, and on this is built a mass-concrete gravity-section wall 11 ft. 6 in. in height, 11 ft. 3 in. wide at the base and 4 ft. wide at the top, provided in the upper part with counterforts at 70-ft. intervals. Cast-iron bollards are anchored to the concrete and the face is protected by 12 in. by 12 in. vertical timbers, extending to 2 ft. 6 in. below low-water spring tides, spaced 10 ft. apart.

Electric supply for the operation of the dock machinery will be obtained from the British Columbia Electric Railway Company. The Government Department will undertake docking and undocking; shipowners will make their own arrangements with repair firms for carrying out work on vessels while in dock. The contract for the construction of the dry-dock chamber was awarded to Messrs. P. Lyall and Sons Construction Company, Limited, while the contract for the pumping plant and equipment has been placed with Messrs. Hodgson, King and Marble, Vancouver, B.C. Construction, which was commenced in 1921, is now well advanced, and it is hoped to complete the undertaking this year.

We publish in Fig. 31, 32 and 33 on the preceding page, and page 454 three views of the work taken early this year. Fig. 31 is a view at the site of the excavation for the power house, all in rock, looking across the dock at the enclosing bund on the south side, the water of Constance Cove and Pilgrim Cove being visible beyond. Fig. 32 shows the head of the dry dock with the floor in place. At this end excavation was nearly all in rock, the nature of the site being well depicted in this view. The view reproduced in Fig. 32 was taken from the head, looking towards the entrance. At the far end, and far left-hand side is the bund behind which the excavation work has been carried out.

THE INSTITUTE OF TRANSPORT CONGRESS.

A CONFERENCE was held by the Institute of Transport at the British Empire Exhibition, Wembley, under the chairmanship of Sir Henry P. Maybury, on Friday, September 19. During the course of the proceedings two papers, "Imperial Communications" and "Transportation in Relation to the Development of South Africa," were read; the first by Air Vice-Marshal Sir Sefton Brancker and the second by Mr. J. A. Harris, of South Africa, in the absence of its author, Mr. F. B. Rees. In his paper Sir Sefton Branker stated that the problem of the busy man was to accomplish everything he wanted to do in the brief span of human life. Our established methods of communication had certain limits and the air now awaited our exploitation. Two distinct forms of air service were available for the future. They were air lines operated by airships, and air lines operated by aeroplanes and seaplanes. For the first time the airship was to be developed as a commercial vehicle in this country, and two big ships were being constructed having details approximately as follows:—Volume, 5,000,000 cub. ft.; length, 700 ft. to 750 ft.; horse-power, 3,600 to 4,000; fuel endurance, 2,500 miles at cruising speed with full commercial load; maximum speed, 70 m.p.h.; cruising speed, 60 m.p.h. The paying load was 16 tons, while the number of passengers was 100. The crew would number 50. Sir Sefton expected the flight to India with such craft to be made in 100 hours with one stop for fuelling. Meantime the old airship R. 33 would be used for an experimental trip. Personally he had little fear for the success of the enterprise. It had been proved since the war that airships need not be housed in a shed except for serious overhaul.

Coming to the question of aeroplane services, he maintained that existing cross-channel transport lines were only experiments. From these efforts a cost of 4*s.* 6*d.* per ton-mile at a speed of 100 m.p.h. over 300-mile stages appeared accurate. One disadvantage at present with aeroplanes was the difficulty of flying safely at night, but despite this fact the United States lines were operating a most successful nightly service on the New York-San Francisco air mail route. To-day small aircraft capable of carrying three passengers, with their baggage, at a speed of 100 m.p.h., could be operated anywhere within reason at about 2*s.* per mile. The author believed Australia was leading the world to-day in the general development of air services for the public. Three long-distance services were available once weekly, the longest being Perth to Derby, a distance of over 1,442 miles, accomplished in 2½ days. The future development of our aeroplane and seaplane transport had been confided to "Imperial Airways"—to whom a subsidy of 1,000,000*l.*, at the rate of 100,000*l.* a year for ten years, had been granted. The company owned, he believed, 15 machines at present. In 1934 they should own at least 100 heavy machines capable of carrying 30 or 40 passengers each. It was not likely, he thought, that a speed of 140 m.p.h. would be exceeded even then. If a comparison could be made between the cost of railways and roads under construction to-day, the expense involved in the creation of these air transport services would appear infinitesimal. It was further necessary to remember that the rapidity and efficiency of our Imperial communications might well be the measure of our success—or our failure—to hold our empire together in the future.

Reading the second paper, Mr. J. A. Harris declared that South Africa scarcely more than a century ago was a wild and little-known country, handicapped by the entire absence of any means of internal transport by water and without harbours or well-defined roads. Until the early sixties the four provinces now comprising the Union of South Africa were without a single railway line. Slow progress characterised the ten years 1860-70, only 68 miles of railroad having been constructed by the latter year. The diamond discovery, followed by the gold reef find in the country opened up a new era of rail progress. For railways a gauge of 4 ft. 8½ in. was at first adopted, but the necessity for extending railway construction through mountainous country into the interior rendered it wise to decide on adopting a standard 3-ft. 6-in. gauge which permitted the use of sharper curves and reduced costs. In 1873 State ownership of the

ELECTRIC FURNACE TEMPERATURE CONTROLLER; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE CAMBRIDGE INSTRUMENT COMPANY, LIMITED, LONDON.

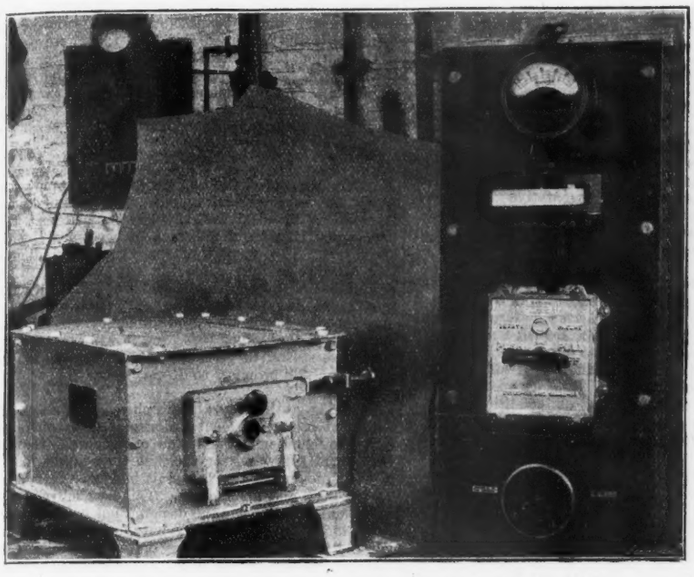


FIG. 1.

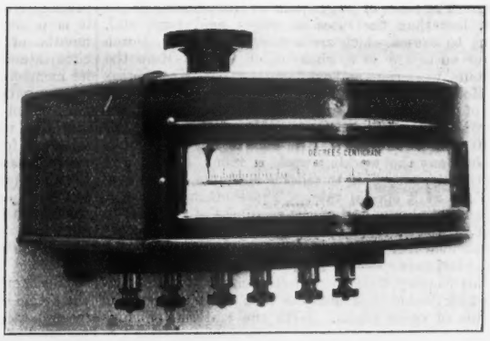


FIG. 2.

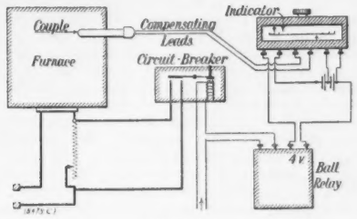


FIG. 3.

lines commenced. The large trade in coal in the colony owed much to railway administration. Recent improvements in material included 50-ton steel bogies and hopper wagons as well as locomotives. The scheduled load of an engine (class 12) on a day's run of 160 miles on the Witbank Line in the Transvaal was 1,500 tons, but 2,000 tons could be hauled. This was a great achievement on a 3-ft. 6-in. gauge line.

The total mileage open for traffic at March 31 last was 11,747 miles, whilst a further 673 miles were under construction. Petrol cars were being used for the transport of passengers and light traffic on some sections with fairly satisfactory results, whilst experiments have been proceeding with a 100-h.p. suction gas engine. Another system receiving attention by the Administration was the railroad type of loco-tractor, the principle being that rails are used for trucks, any tractor being employed. Wheel-ways 2 ft. wide, were used by the locomotive. It was claimed that, utilising 16-lb. rails, road-rail lines could be built for 1,000*l.* per mile. The inauguration of electric traction had commenced on the line between Glencoe and Pietermaritzburg, the section being 171 miles long. Regarding waterways, the Durban graving dock nearing completion would be one of the largest in the world, the effective length being 1,150 ft., its width 110 ft., and its depth over sill 41 ft. In view of these developments, South Africa held out the greatest attractions to visitors and settlers, and history would be able to record that the railways and harbours of the country played no inconsiderable part.

A general discussion then took place on the papers. Col. Bristow opened the debate and stated that air transport rather than communication was the more important aspect. Major J. H. Scott stated that his particular study was the airship and he believed a cost per ton-mile of 2*s.* was possible with this type of craft. Sir William Clarke was interested in Imperial development and instanced the unfavourable conditions of China with regard to India, due to the latter's superior transport. Sir R. Blankenberg added some detail of South African conditions. General Freeland indicated progress in India and explained that a cost of 10,000*l.* per mile prohibited ordinary tracks in some cases. Even 2-ft. 6-in. gauge lines cost up to 5,000*l.* per mile. The road rail system offered the proper alternative, Sir T. R. Wynne, of the Bengal Nagpur Railway, stated that India was now unrecognisable due to railway progress. Owing to the railways the country had now a steelwork meeting their own rail requirements in steel. From what he had heard he believed the South African rates were not so favourable as those in India. The Government had first supplied the capital for development and had been justified in time by results. Mr. A. H. Tatlow referred to the white-population scarcity in South Africa. Mr. Kelway Bamber was interested in the extent, if any, of the branch line drain on main line profits, and gave some figures. A steam-rail car had been proposed and tests were now taking place with a view to economy. Mr. E. S. Shrapnell Smith, Vice-President of the Institute, criticised the air schemes from the point of view of practical utilities, *e.g.*, entrance, egress, cooking, &c., and on the question of cost. Luncheon followed, in the course of which the toast "Imperial Transport" was given by Mr. Harry Gosling, Minister of Transport, and Mr. D. Ross Johnson. Responses followed from Sir R. A. Blankenberg and Sir T. R. Wynne. The "Institute of Transport" was proposed by Lieut.-Col. J. Sealy Clarke, and was responded to by Sir Henry P. Maybury. A visit to a number of stalls at the Palace of Engineering concluded the Congress.

ELECTRIC FURNACE TEMPERATURE CONTROLLER.

IN many industrial processes the temperature of the materials involved must be kept within narrow limits if satisfactory results are to be obtained, and for the highest efficiency it is necessary that such control should be automatic in action. An apparatus for this purpose has recently been developed by the Cambridge Instrument Company, Limited, of London. Fig. 1 above shows the standard outfit for controlling the temperature of an electric furnace. It will be seen from Fig. 3 that a thermo-couple, mounted within a protecting tube, such as porcelain, is connected by compensating leads to an indicator, shown in Fig. 2. This indicator is a high-resistance moving-coil galvanometer, fitted with a calibrated temperature scale, over which the galvanometer pointer travels. Near the end of this pointer a light thermo-couple is attached, which is electrically connected to a relay controlling the main circuit, supplying heat to the furnace. A small electrically-heated coil connected across a resistance or transformer is set to the point on the scale at which it is desired to maintain the temperature. When the temperature reaches this value the thermo-couple on the pointer is heated by proximity to the hot coil and the E.M.F. set up in it energises the relay which is worked with a pressure of 4 volts. This causes the electro-magnet in the circuit-breaker to attract the armature against the small spring, shown in the diagram, and break the low resistance supply conductor circuit to the furnace. The high resistance wire shown then completes the circuit, supplying less current to the furnace, when the temperature commences to fall. Immediately this becomes appreciable, however, the thermo-couple on the pointer cools, so that the extra E.M.F. to the relay is no longer maintained. The terminal contact in the relay is then broken causing the electro-magnet in the circuit to release hold of the armature, which flies back under the action of the small spring. The low resistance-circuit is then completed, again bringing up the temperature to the desired value. The range of variation in this type of control can be reduced to a very small value, while the temperatures over which control can be exercised range upwards from 1,000 deg. F. The apparatus may be seen at the British Empire Exhibition.

LOUGHBOROUGH COLLEGE.—The Calendar of Loughborough College, Leicestershire, has now been published for the session 1924–25 by the Echo Press, Loughborough (price 3*s.* 6*d.* net), and contains very complete information regarding the facilities there available for technical education.

SELL'S DIRECTORY OF REGISTERED TELEGRAPHIC ADDRESSES.—The midsummer supplementary issue for 1924 of Sell's Directory of Registered Telegraphic Addresses has now been published and contains a list of all the new telegraphic addresses registered at the Post Office and received from H.M. Postmaster-General for publication since the beginning of the present year.

WATER TURBINES FOR NEW ZEALAND.—Vickers Limited, hydro-electric department, have received an order from the Government of New Zealand for two large water turbines, each with an output of 12,650 h.p. to be installed at Lake Coleridge, in the South Island. They will provide power for Christchurch, Ashburton, Timaru and district. The turbines will be constructed at Barrow-in-Furness.

RAIL TRANSPORT OF LONG GIRDERS.—It would appear that the problem of carrying large pieces of machinery and other constructions by rail depends for its solution as much on the ingenuity with which such loads are mounted for carriage as in the provision of special trucks. As an illustration of this point the London Midland and Scottish Railway Company recently transported two girders, each exceeding 97 ft. in length, from Reddish to Chesterfield for the Stavely Coal and Iron Company. These were centrally loaded, each on a well trolley to which were attached runners to protect the overhang. Considering that the weight of each beam was 17¼ tons, while the height was 9 ft., this accomplishment must be regarded as a very creditable performance.

ARMCO IRON.—Engineers will be interested to learn that arrangements have recently been made for the production in this country of rust resisting Armco ingot iron. The Armco International Corporation has established an office at Pinner's Hall, Old Broad Street, E.C. 2, under the management of Capt. R. Terrell, and Shelton Iron, Steel and Coal Company, Limited, Stoke-on-Trent, and the Scottish Iron and Steel Company, Limited, of Glasgow, will undertake the manufacture of this brand of iron. Armco iron tubes will be made by the Scottish Tube Company, Limited, of Glasgow, and wire by the Whitecross Company, Limited, of Warrington. Messrs. Tyer and Co., Limited, Dalston, London, E. 8, have been appointed selling agents to railway companies.

LABOUR NOTES.

The easier labour conditions which some Continental shipbuilding and ship-repairing industries enjoy, unquestionably account very largely for our failure to hold our own in recent international competitions for work. The rates of wages paid in Holland are 10 per cent. less than the rates of wages paid here, and, owing to causes which are not at all obscure, Dutch labour costs are as a whole much lower. Here the 47-hours' week rules and overtime is unpopular, whereas in Holland the working day—which is nominally one of 8 hours—is actually, in some cases with the approval of the law and the consent of the unions, one of 10 hours. Moreover, overtime is not unpopular. In Germany the working week is much longer, and overtime is, according to reliable accounts, not always paid for at a special rate. The economic effect of these longer hours and of the readiness of the men to work overtime, is in no need of emphasis. Another thing which tells in favour of Dutch competition is the straighter, so to speak, organisation of shipyard labour. In this country there is a multiplicity of trades, each of which jealously guards its own craft against the inroads of other crafts. With the material of ships in a state of constant change "lines of demarcation"—to use the trade union phrase—between the various crafts are not unnaturally frequently in dispute. Two trades claim a job, and while they argue about the matter, the work stands still. The men are, of course, losers in the sense that while they are idle they are in receipt of no wages, but a much larger loser is the employer whose operations are, to this extent, crippled until the disputants come to an arrangement. In Holland shipbuilding and ship-repairing labour is divided—if our memory serves—into three main groups, and within the limits of each of these groups workers are, to all intents and purposes, interchangeable. Instead of standing off and waiting till men belonging to some other trade arrive to perform a simple operation which prevents him carrying on, the Dutch shipyard worker does the little job himself and then proceeds with his own. In this way continuity of operations is maintained, and the effect is seen in the much better deliveries which Dutch ship repairers are usually able to give. In most Dutch shipyards the organization of the iron workers is also much better from the point of view of speed and economy of production.

As a rule, when these things are pointed out to British trade unionists, the rejoinder is made that the foreign workers' standard of life and working conditions is low and ought not to be held up to him as an example. Whether they are unduly low or not is a matter about which foreign workers might have something interesting to say. But the defect of the British workers' argument of this kind is that it misses the point—which is that through these easier conditions which the Dutch shipbuilder and ship repairer enjoy with the consent of the Dutch trade unions, British workers are in great danger of finding their occupation gone. Nobody is seeking to reduce the British workers' rates of wages, but everybody concerned realises that labour costs must be reduced in other ways. The Dutch practice shows how this may be done, and British trade unionists would, therefore, be much more profitably employed in their own interests in ascertaining how the system might be applied to their industry than in taking the line that they do.

Demarcation troubles are not, of course, new. They have been with us for many years. An effort ought now, however, to be made by the trade unions to end them once and for all. Moreover, less ought to be heard in Labour circles about maintaining the 48 hours' week as an example to other countries, by ratifying the Washington Convention. No haste is apparent anywhere else to give the Convention the support of legislation. On the contrary, everywhere there seems to be a disposition to evade it. In sheer self defence, therefore, British trade unionists ought to take up the position that if there is to be ratification of the Convention its application ought to be simultaneous in all countries which were represented at Washington. Whether British shipbuilding and ship-repairing regain their old pre-eminent positions or go to the wall depends upon labour's attitude towards these new problems, and it is to be hoped that the movement's representative men will speedily realise this, and take the necessary action. The employers have done splendidly in one of the most difficult periods in the history of industry, but it is clear that they can do little more without the co-operation of the workers.

Man and Metal, the official organ of the Iron and Steel Trades Confederation, regards the sectional strikes which have recently taken place in the heavy steel trades as deplorable from every point of view. It is difficult to understand, it says, with industry in its present state, many works standing idle, a large amount of unemployment and abnormal competition following nearly three and a-half years of the most acute trade depression, how any responsible trade union representative, with a knowledge of the facts and circumstances, could commit such a blunder as to throw men on the streets in respect of a wages dispute when other alternatives are available. By way of contrast, it is pointed out that the Confederation has, after months of negotiation in most difficult and trying circumstances, come to an arrangement under which its members get, without the loss of a day, what the large numbers of men who are walking the streets of Rotherham are alleged to be in dispute about. A disability under which the iron and steel trades have laboured for years, and which has caused a loss of many thousands of pounds of union funds, in addition to much more in wages, is, it is stated, that various sectional unions, mainly representative of outside trades without practical knowledge of the iron and steel industry, have followed a policy ill-conceived in respect of its objects and deplorable in its results.

The same organ of trade union opinion condemns the action of the Labour members of Hull City Council in supporting the decision to accept a German tender for steel rails in preference to a British tender which was a little higher. "We do not know," it says, "what kind of argument is being used for this Hull Labour policy of buying in the cheapest market irrespective of circumstances or conditions under which the commodity is produced. Cheapness which is based upon a low standard of life and conditions of employment for workpeople can never be a part of Labour policy, and just as we endeavour to protect trade union standards and the employers who adopt them in respect of competition in the home market, so we are justified in demanding that the same principle shall be applied in relation to our trade with other countries. We suggest to the Hull Labour councillors," *Man and Metal* concludes, "that the present competitive conditions are not fair to the British steel worker, and that their policy in the matters referred to can hardly be defended on the grounds, either of trade union principles, or sound national economy."

From two points of view, the rates of wages which are being paid by municipal authorities are unfair to ordinary employers, and sooner or later effective protests are bound to be made against them. The extravagant remuneration is keeping local rates higher than ought to be the case, and to that extent the already heavy burden of trades which have to compete with foreign manufacturers is increased. The high wages paid are also a fruitful cause of discontent amongst workers who are employed in unsheltered industries. For these and similar considerations the trade unions have, of course, not the slightest regard. Without taking into account what must be the ultimate effect of their action they are almost everywhere forcing up wages in sheltered trades, and then fixing the high rates as standards to which employers in unsheltered trades ought to conform. At Manchester, for example, the Electrical Trades Union is pressing a claim for an advance of 4*d.* per hour for the electrical workers in the Tramways Department whose wages, have up till now, been determined by the practice in general engineering. The municipal authorities have refused to concede the increase, and the members of the union in the district have passed the following resolution :—

"That the time is now ripe to establish a common understanding between all our members employed by the Manchester and Salford Corporation to assist one another on wages questions and working conditions under discussion, and that a committee be formed to meet when any trouble arises."

A committee has been formed to deal with this particular trouble. No doubt, when joint action of this kind has been effective over a fairly large area, the wages paid in the sheltered industries will be assumed to be the standard for the unsheltered industries. The unsheltered industries cannot afford to pay these high rates, and if they are pressed to do so they will be obliged to shut down. The ultimate effect of all action of this kind must, therefore, be, as Mr. Frank Shearman suggested the other day at Cardiff, to leave the workers as a whole not better, but much worse, off than they were before.

Mr. J. G. Pease, the Umpire appointed under the Unemployment Insurance Acts, has given two interesting decisions on points referred to him by the Court of Referees. In one of the cases, benefit was claimed on behalf of men employed by the South Liberty Collieries, Bristol, who went on strike because, they said, the employers had contravened the National Agreement of 1924. The employers refused to pay wages in accordance with the Agreement, saying that they were not contracting parties to the Agreement. When the terms of the Agreement were settled the Bristol Colliery Owners were members of the Mining Association, and the Umpire says that although they gave notice of resignation before the Agreement was formally signed, their resignation did not become operative immediately as 12 months' notice was required. Accordingly, although the Bristol Colliery Owners Association protested that they would not be bound by any national wages agreement which increased the wages payable in that district, being members of the Mining Association, they were parties to the National Agreement. "In my view," concludes the Umpire, "the stoppage of work was due to an employer acting in a manner so as to contravene the National Agreement to which the employers and the employees were contracting parties, and benefit is payable."

In the other case, the applicants for unemployment pay were employees of certain steel manufacturing firms in the Sheffield District, who claimed that they had struck because of a breach of agreement by the employers. The purport of the Umpire's finding in this instance is that while the men engaged in the production of steel are entitled to benefit, the maintenance staffs are not. The case, however, raises questions of importance and difficulty on the construction of the Act of 1924, and it will be necessary, Mr. Pease states, to give his reasons for the decision at length. He promises to do this later.

Speaking at Merthyr, Mr. John Marchbanks, the President of the National Union of Railwaymen, said that they had now taken the offensive for the first time since 1919, and for the first time in the history of their movement the proposals had been formulated by the rank and file as such. This new movement, if successful, would mean, he declared not only improved conditions for railwaymen, but for other workers. Alternatively, it would mean defeat for railwaymen and the putting back of other workers of the country. It was the bounden duty, therefore, of every member of the organisation to back the proposals for all they were worth.

The Scottish Regional Wages Committee for the building trades has arrived at an agreement on the subject of working hours in accordance with the provisions contained in the constitution of the National Wages and Conditions Council. The agreement is as follows :—

"(1) That where the 44-hours week (eight hours per day for the first five days and four for Saturday) was in operation on May 22, 1924, the same shall be maintained, with the proviso that on jobs where no artificial light is reasonably possible the hours may be reduced by half-an-hour during the first five days of each week during January and December, thus making 41½ hours per week, with half-an-hour for meals.

"(2) That where other than 44 hours per week was in operation on May 22, 1924, the normal working week shall not exceed 46½ hours, and the same shall be maintained until altered by mutual agreement. In this case the operatives will be entitled to claim two meal hours.

"NOTE.—This clause will not apply where the extended number of hours were being worked in violation of any understanding which had existed in the locality.

"(3) The provision for the half-hour for meals in Clause 1 is to be subject to ratification by the National Wages and Conditions Council."

The Ministry of Labour states that the number of unemployed persons on the register of Employment Exchanges in Great Britain on September 15 was 1,164,000—873,300 men, 39,400 boys, 217,500 women, and 33,800 girls. The total number of unemployed persons on September 8 was 1,163,648, and on December 31, 1923, 1,285,623.

UNIVERSAL DIRECTORY OF RAILWAY OFFICIALS.—The thirtieth annual edition of the Universal Directory of Railway Officials has now been published, and differs from preceding issues mainly in the arrangement of the personal index. This has been compiled so as to show after an official's name a letter and a number. The letter indicates which of the 10 sections of the work contains the particular railway he is connected with, and the number identifies the company. The volume is published by The Directory Publishing Company, Limited, 33, Tothi'l-street, S.W.1; price 20*s.* net.

OIL ENGINE TRADE.—That the long looked for recovery in the oil engine industry throughout the country is in view receives some support from the fact that during the month of July a record trade was done, since the great slump which commenced over three years ago, by Messrs. L. Gardiner and Sons, Limited, of Patricroft, Manchester. A feature of the improvement is that engines have been ordered for a wide variety of purposes from small house lighting sets of the two and three horse-power type, to engines of over 200 brake horse-power for the propulsion of commercial craft.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—While conditions in several of the lighter sections devoted to machinery and tool production point to the prospect of improved business towards the end of the year, the gloom in heavy iron and steel manufacture is unrelieved. The possibility of a settlement in the dispute affecting the three largest basic steel-producing concerns in the Sheffield district seems to be drawing nearer, as the result of statements published by the employers' and the men's representatives. Meanwhile the demand for common billets, hematites, and pig iron continues at one of the lowest levels recorded for many months. Several hundred more operatives have been thrown idle during the past fortnight, bringing the total of unemployed in Sheffield to 27,000. The measure of improvement brought about since the worst period of the slump is, however, indicated by the fact that, during the past four years, close upon 43,000 operatives have been absorbed into the local staple trades. A revival of Continental competition in basic steel has reacted adversely on local values, which, though declared by producers to be mainly unremunerative, still show a downward tendency. Hard basic billets are quoted at 9*l.* 10*s.* per ton, soft basic billets 8*l.* 5*s.*, West Coast hematites 5*l.* 10*s.*, East Coast hematites 4*l.* 15*s.*, Lincolnshire and Derbyshire No. 3 foundry, each 4*l.* 7*s.* 6*d.*, and Lincolnshire and Derbyshire forge iron, each 4*l.* 5*s.* Good progress is being made with South Yorkshire colliery developments, which are calling for supplies of pit gear, ropes and tools. The extended provision of miners' houses is also proceeding apace. Plant at Sheepbridge, Derbyshire, for the manufacture of centrifugal castings is now in successful operation. The manufacture of mining and quarrying tools is making good progress. The report of one of the leading firms dealing in this class of product shows that it has had one of the most successful years in its history. Electrical and textile engineers continue to book fairly substantial orders for export, despite the difficulties of foreign currency and foreign tariffs. The heavy engineering branches are making moderate headway in the face of discouraging obstacles. Railway work is less abundant, but by no means all the latest requirements of former customers are going to Continental competitors. French automobile engineers are in the Sheffield market for rolled steel of guaranteed quality.

South Yorkshire Coal Trade.—The demand for best steams is below production capacity, though business on a substantial scale continues to be done with France, Holland, Belgium, Sweden and Germany, while exports to Russia tend to expand. The home demand for manufacturing fuel is far from brisk, but deliveries are maintained at a fairly high level. Improvement in cobbles, nuts and slacks is deterred by the offer of inferior qualities at cheap rates. An effort made by individual collieries to raise the price of best house coal has not affected official quotations, a surplus tonnage still being available. Coke shows signs of an early improvement. Quotations: —Best branch handpicked, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 28*s.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 25*s.*; Derbyshire best small nuts, 15*s.* to 17*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire hards, 21*s.* to 22*s.*; Rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; Nutty slacks, 12*s.* to 14*s.*; smalls, 6*s.* to 8*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is very little new to report of Cleveland pig-iron. Supplies are by no means plentiful, and indeed No. 1 is extremely scarce, but customers are slow to purchase, and values continue to droop. Whilst, however, conditions point to a continuation of the downward movement in prices, it is fully realised that little increase in demand is needed materially to alter the situation and to cause quotations to stiffen. No. 1 is very difficult to obtain under 87*s.* Most makers ask 82*s.* for No. 3 g.m.b., but 81*s.* 6*d.* is stated to have been accepted, and buyers are inclined to hold off in anticipation of a still lower figure being named. Foundry No. 4 is quoted 81*s.*; and No. 4 forge, 80*s.*

Hematite.—The East Coast hematite branch is handicapped by large and steadily increasing stocks, and with buyers exercising extreme caution in their dealings, prices are weak. Producers are very unwilling to make price concessions, but they are understood to have accepted orders at below recognised market rates, and merchants are keen to sell at a little below the figures generally named. No. 1 is put at 90*s.* 6*d.*, and mixed numbers are quoted at 90*s.*

Foreign Ore.—Business in foreign ore is hardly heard of, and definite contract prices are not easily fixed. There are sellers on the basis of best rubio at 22*s.* c.i.f. Tees, but probably orders could be placed on lower terms.

Blast-furnace Coke.—Durham blast-furnace coke is in only moderate request, and prices tend easier. Good medium qualities run from 25*s.* 6*d.* to 26*s.* delivered to local users.

Manufactured Iron and Steel.—Sheet makers are fully employed, and they report continued considerable inquiry, but in nearly all other branches of finished iron and steel, work is slack and sales are slow. A good deal of foreign semi-finished steel is still being brought here. Export trade is exceedingly difficult to secure, and home order sare quite scarce. For overseas trade, quotations are matters of individual negotiation, but for home business, the following figures still rule: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel rivets, 14*l.* 15*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 18*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No improvement of any kind can be reported in connection with the Scottish steel trade, and the outlook is as dull and cheerless as ever. Buyers with orders to place keep clamouring for better terms in view of the low offers from the Continent, but as the lots do not make up a heavy tonnage and as full oncost charges are running, producers find it impossible to do much in the way of shading prices. Already the current quotations do not show much, if any, margin, and further concessions would just mean a balance on the wrong side without any doubt. If consumers were ordering freely and the tonnages were heavy so as to ensure the steady and full running of plant, more favourable terms might be possible, but, at present, little in that direction can be expected from producers. The demand for plates and sections, at the moment, is just about as poor as it has been for some time, and even the general enquiry shows no signs of improving, either on home or export account. The black-sheet trade continues to exhibit activity, and not only in the lighter gauges, the heavier sorts being in rather better request. The following are the current market quotations:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{7}{16}$ to $\frac{1}{8}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—Movement in the malleable-iron trade of the West of Scotland continues to be very restricted, and little fresh business is reported. Home consumers are not placing many orders and foreign lots are difficult to pick up. In the re-rolled steel branch the demand is also very limited, and although there are a fair number of orders on hand there is no pressure felt and prospects are not bright. Prices are unchanged, with "Crown" bars quoted at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-iron Trade.—It is not possible yet to report any improvement in the state of the Scottish pig-iron trade and conditions would almost seem to be worse this week. Dealings all over are very poor, and the demands from both home and foreign buyers are of the smallest proportions. The lower prices now being quoted by producers have failed to revive buying and the present outlook is indeed very poor. The following are the market quotations:—Hematite, 4*l.* 15*s.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 16*s.* 3*d.* per ton, and No. 3, 4*l.* 11*s.* 3*d.* per ton, both on trucks at makers' yards.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—No improvement can be recorded in the general condition of the Welsh coal trade. Indeed, on balance, the position is, if anything, worse. Inquiries are limited and the amount of new business passing is extremely small. In fact, collieries are only managing to keep their pits working intermittently by the shipment and railing of contract supplies. Stoppages throughout the coalfield are of frequent occurrence, and already a number of pits have been closed down and others are still following suit. The Merthyr district up to the present has been hardest hit by the uneconomic condition of the coal trade. In addition to the closing of the Bedlenog pits, which throws 2,000 men out of employment, it has now been decided to shut down the Castle Pit of Level and the Gething Colliery, which also renders idle about 2,000 men. The Lucy Drift, of the Thomas and Llewellyn Colliery Company is also to close and between 500 and 600 men will be idle. In this district alone some 7,000 men have been thrown out of work, while at least another 10,000 men have been rendered idle in other parts of the coalfield. Notwithstanding the loss of production caused by the wholesale stoppages of pits, available supplies of coal are generally more than sufficient to meet the limited demand. The only class of coal which is scarce is anthracite, and for this prices are up to 62*s.* 6*d.* for French nuts. Bituminous and dry sized coals, too, are in moderate request and none too freely offered, with the former ranging from 21*s.* to 24*s.* for nuts and the latter from 25*s.* to 28*s.* All grades of steam are, however, excessive, and colliery salesmen, in the majority of cases, are pressing contractors to take deliveries in preference to selling in the open market. Best Admiralty large is worth no more than 27*s.* 6*d.*, and Monmouthshires range from 23*s.* to 25*s.*, while smalls rule from 10*s.* to 15*s.* 6*d.*, according to quality. Buyers with definite business, able to give quick shipment, can secure their requirements at concessions of 6*d.* to 1*s.* on the quoted prices, and business, under these conditions, is entirely a matter of individual negotiations.

NOTICES OF MEETINGS.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, September 30, at 6.30 p.m., at 85-88, The Minories, Tower-hill, E.1. "Marine Oil Engines: Practical Notes on Bearing Adjustment." By Mr. John Lamb.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS (INCORPORATED).—Wednesday, October 1, at 6.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Open discussion on "The Possibilities of Railway Signalling from an Economic Point of View." The subject will be introduced by the President.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, October 2, at 5.30 p.m., in the Society's Library, 7, Albemarle-street, W.1. "Common Sense and Aeronautics." By Lieut.-Colonel H. T. Tizard, A.F.C.

THE INSTITUTION OF MINING ENGINEERS.—Annual General Meeting, Thursday and Friday, October 2 and 3, in the Conference Hall No. 2, British Empire Exhibition, Wembley. Thursday, October 2, at 11 a.m. Presidential address by Dr. J. S. Haldane, F.R.S., on "The Values for which the Institution Stands." Papers to be discussed: (1) "Salt Treatment for Miners' Fatigue," by Sir Josiah Court, L.R.C.P., M.R.C.S. (2) "The Food Requirements of Coal Miners." By Professor K. Neville Moss, M.Sc. (3) "The Mechanical Efficiency of the Human Body during work in High Air Temperatures," and "The Physiological Standardisation of the Kata-Thermometer," by Professor K. Neville Moss. (4) "The Application of Gas Analysis to the Detection of Gobfires," by Mr. John T. Storrow and Mr. J. Ivon Graham, M.A., M.Sc. Friday, October 3, at 10.30 a.m. (5) "Economics of the Coal-Mining Industry," by Mr. Evan Williams. (6) "The Valuation of Mines and Minerals, and the Relation of Income Tax to such Valuations," by Mr. R. L. A. Dron, B.Sc. The following papers, read before the Empire Mining and Metallurgical Congress, June, 1924, submitted for further discussion: (*a*) "The Ventilation of Mines," by Professor Douglas Hay, B.Sc. and Mr. Robert Clive. (*b*) "The Rhymney Valley Compressed-air Installation," by Mr. Edmund L. Hann. (*c*) "Problems of Mechanical Coal-mining," by Mr. Sam. Mavor. (*d*) "The Preparation of Coal for the Market," by Mr. F. S. Sinnatt, M.Sc., and Mr. H. Eustace Mitton, M.Inst.C.E.

THE DIESEL-ENGINE USERS' ASSOCIATION.—Friday, October 3, at the Engineers' Club, Coventry-street, W.1. "The Significance of Exhaust Temperature," by Mr. P. H. Smith.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 3, at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecture, "Explosions, Terrestrial and Celestial," by Professor A. W. Bickerton.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, October 4, at 4 p.m., in the College of Technology, Sackville-street, Manchester. Presidential address by Mr. R. A. Miles. Followed by a paper on "John Wilkinson," by Mr. J. P. Bedson.

PHYSICAL CHEMISTRY OF IGNEOUS ROCKS.—A general discussion of the physical chemistry of igneous rock formation is to be held in the rooms of the Geological Society, Burlington House, London, on Wednesday, October 22, beginning at 3 p.m. Contributions are expected from Dr. J. S. Flett, Professors C. H. Desch and J. W. Gregory, and other authorities. Further particulars relating to the meeting may be obtained from Mr. F. S. Spiers, 90, Great Russell-street, London, W.C. 1.

NEW FRENCH NAVAL CONSTRUCTION.—The French Government has announced that the two new cruisers Duquesne and Tourville will have the following characteristics: Length, 607 ft.; beam, 29 ft.; draught, 20 ft.; i.h.p., 130,000; speed, 33 knots; armament, eight 8-in. guns mounted in four double turrets, eight 2·9-in. and eight anti-aircraft guns; six 21·6-in. torpedo tubes in two groups of three tubes each. The crew will be 600, and great attention has been paid to making the living conditions as comfortable as possible.

THE ITALIAN TELEPHONE SERVICE.—Tenders have now been invited by the Fascist Government for the purchase by private firms of the Italian Government telephone system. This is another step towards the transfer of Italian internal communications to the control of private organisations with the object of securing efficient management and development. The country is to be divided into five sections for the purpose, and these are to be put into the control of different organisations. Conditions attaching to the purchase are that the plant will be developed, that the capital shall be Italian, and that rates to users shall be reduced.

THE ROYAL TECHNICAL COLLEGE, GLASGOW.—On his appointment as Professor of Electrical Engineering in The Royal Technical College, Dr. S. Parker Smith made an appeal through the Council of the British Electrical and Allied Manufacturers' Association to British firms for donations of plant to put the equipment of the electrical laboratories into a state representative of the best modern practice. The leading members of the B.E.A.M.A. made immediate and generous response, with a resulting benefit to the many electrical students in Glasgow. Professor Parker Smith has now obtained what are amongst the best equipped laboratories in the country, and he desires on behalf of the College to express appreciation of what has been done by the B.E.A.M.A. and its members as a result of his suggestion.

THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, BRITISH COLUMBIA.

(*For Description, see Page* 449.)

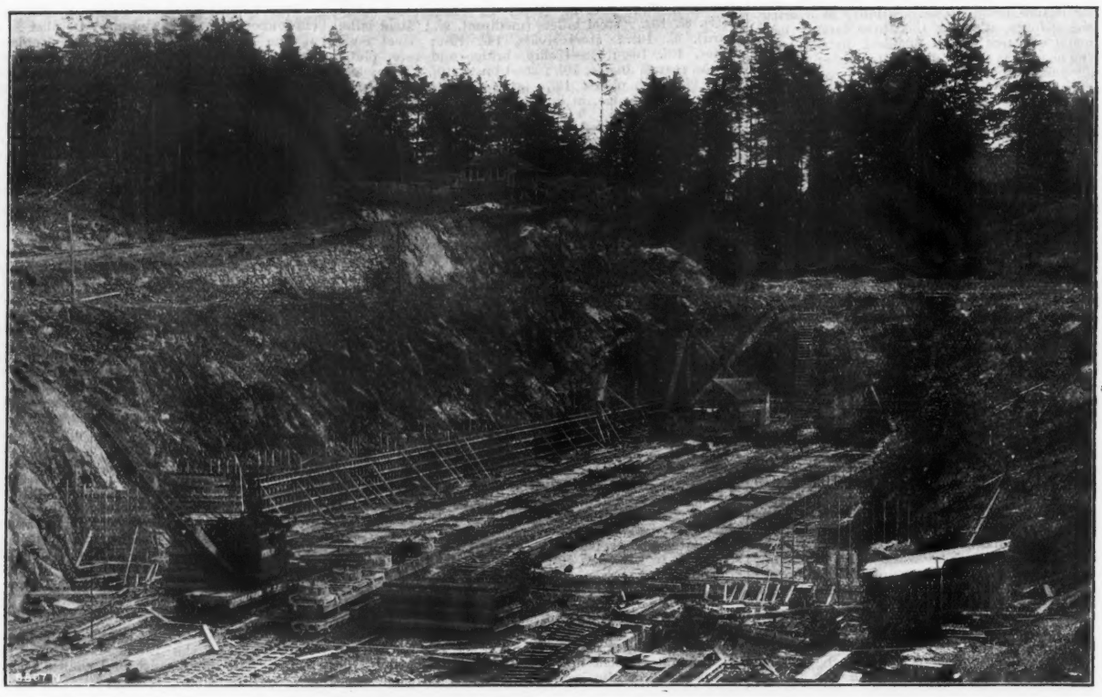


FIG. 32. VIEW OF WORK ON HEAD OF DRY DOCK.

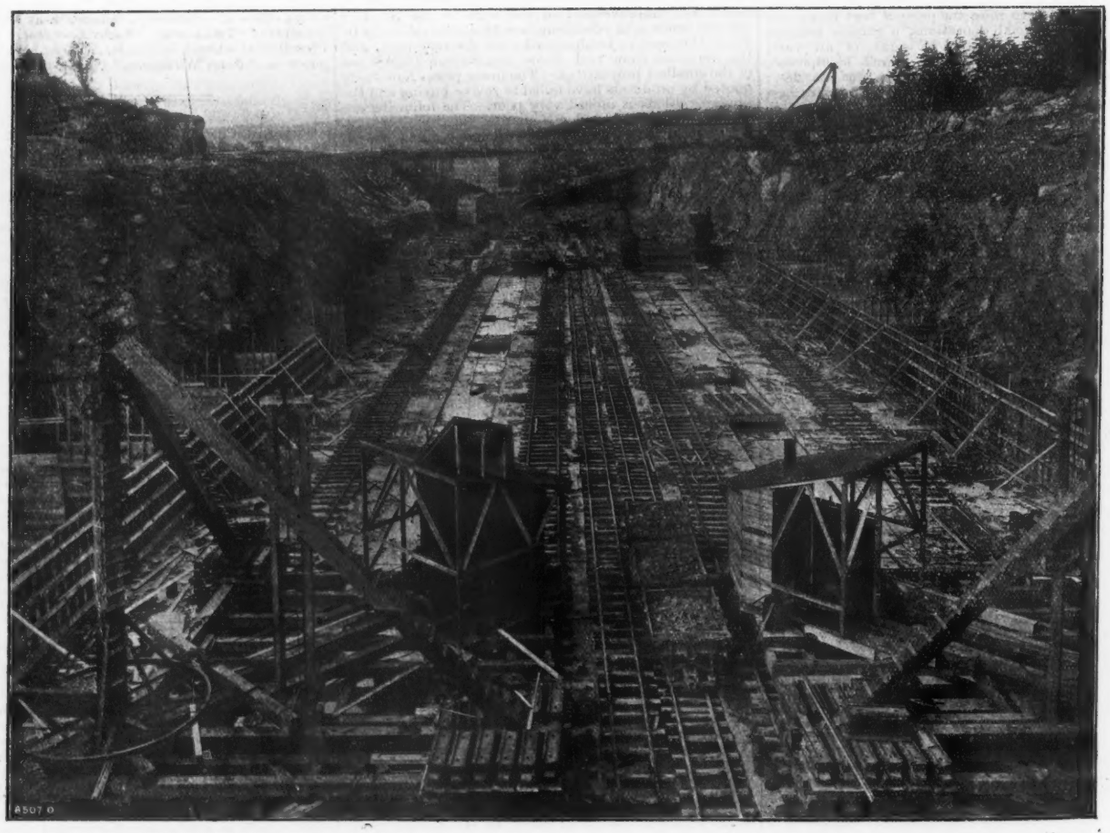


FIG. 33. VIEW TAKEN FROM HEAD AND LOOKING TOWARDS ENTRANCE OF DOCK.

THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, BRITISH COLUMBIA.

(*For Description, see Page 449.*)

Fig. 1.

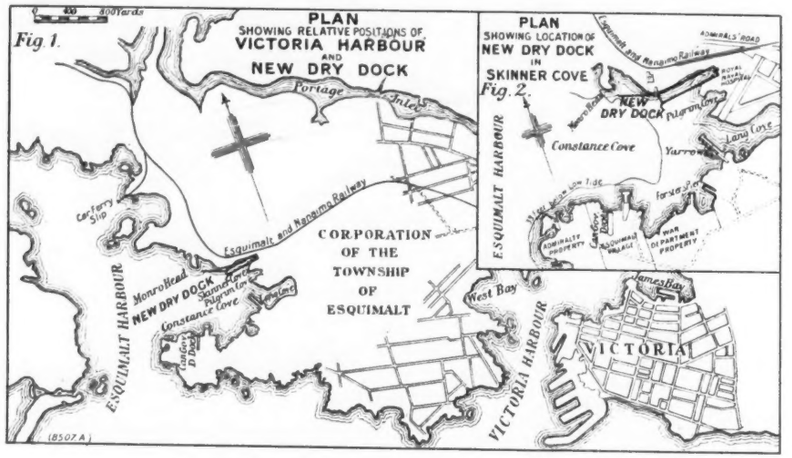


Fig. 2.

Fig. 3.

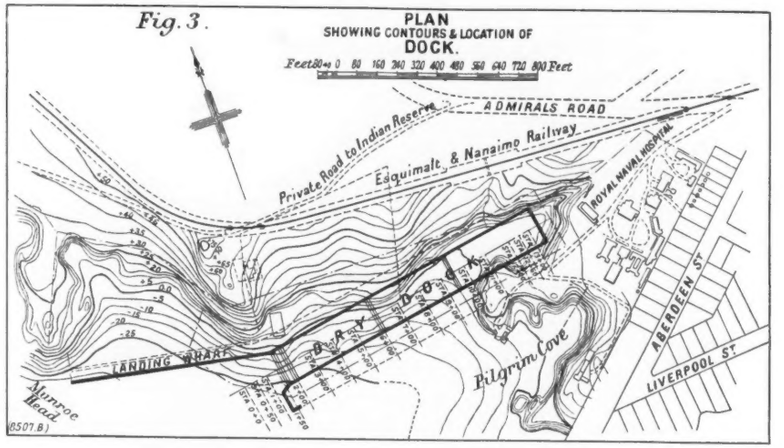


Fig. 4. GENERAL PLAN OF DOCK.

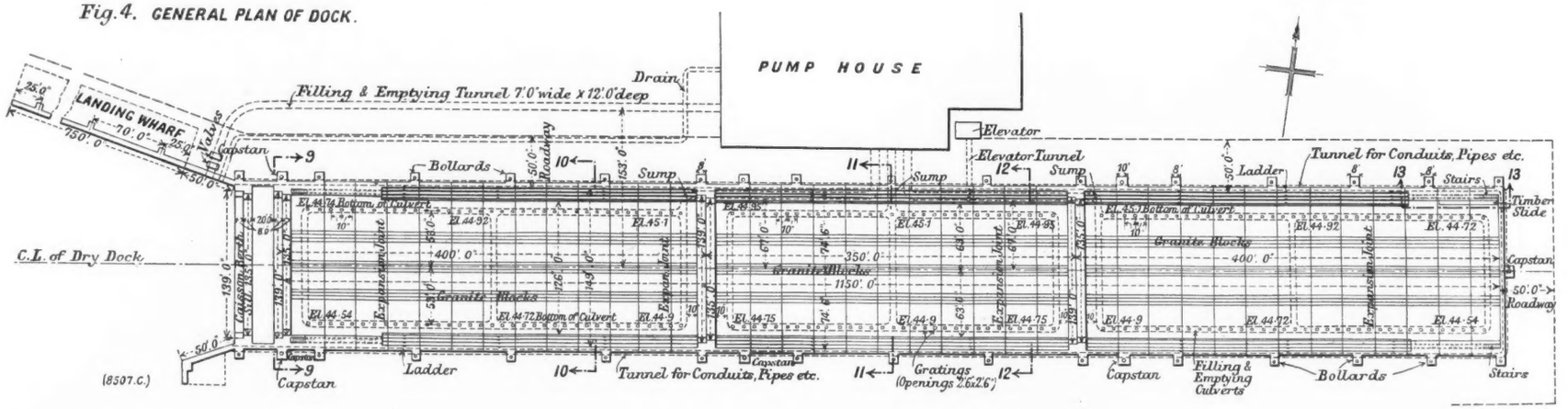


Fig. 5. CROSS SECTION AT 9.9.

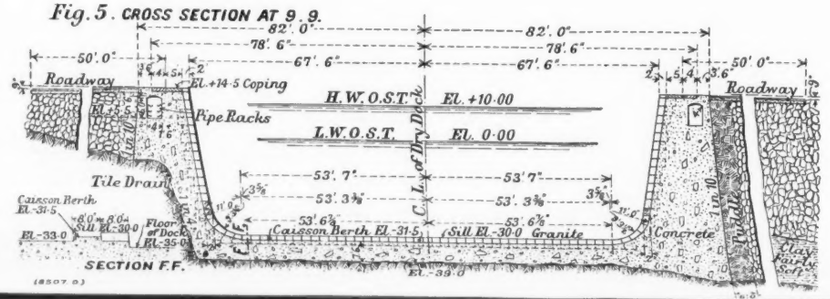


Fig. 6. CROSS SECTION AT 10.10.

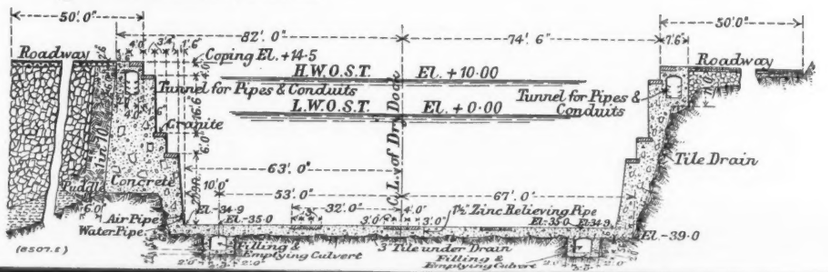


Fig. 7. CROSS SECTION AT 11.11.

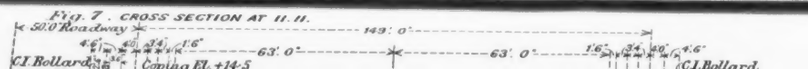
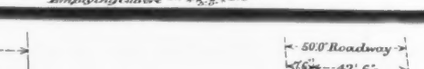
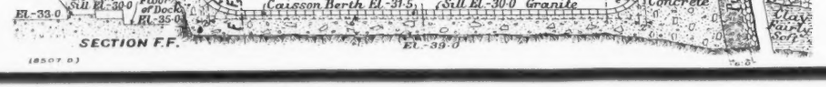


Fig. 8. CROSS SECTION AT 12.12.





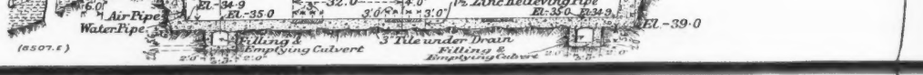


Fig. 7. CROSS SECTION AT 11.11.

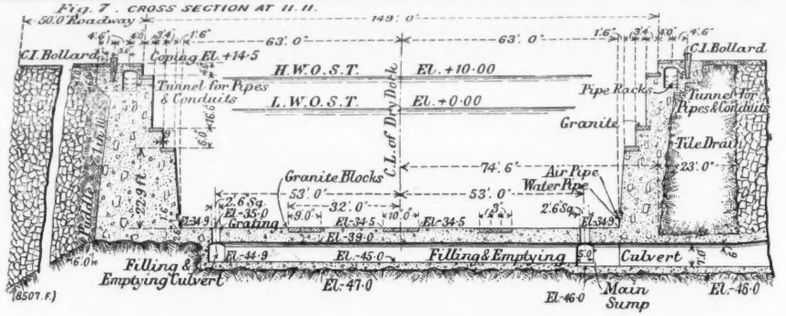


Fig. 8. CROSS SECTION AT 12.12.

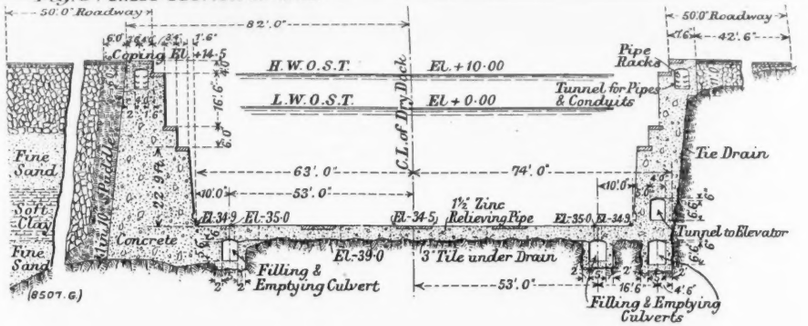


Fig. 9. ELEVATION AT 13.13.

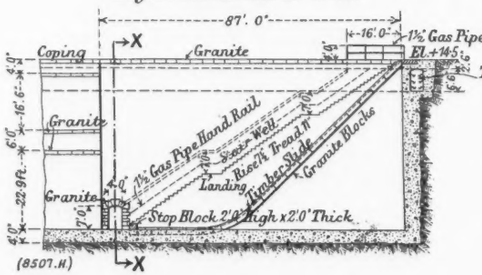


Fig. 10 SECTION AT X.X.

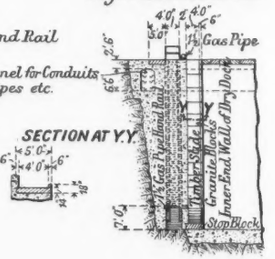
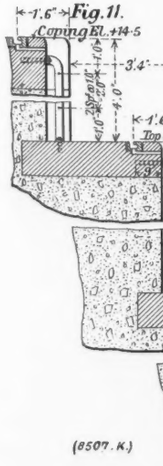


Fig. 11.



DETAIL OF ALTAR LADDERS.

Fig. 12.

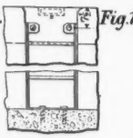


Fig. 13.

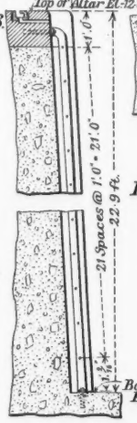
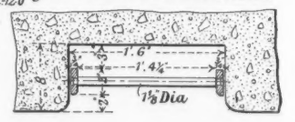


Fig. 14. DETAIL OF LADDER RUNG.



CAST IRON HOLD FAST.

Fig. 15.

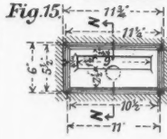


Fig. 16.

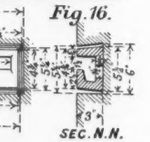


Fig. 17. LONGITUDINAL SECTION A.A.

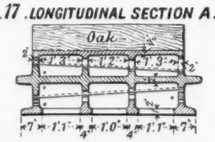


Fig. 18. SIDE ELEVATION.

Fig. 19. INVERTED PLAN OF TOP CASTING.

Fig. 22. PLAN.

Fig. 26. DETAIL AT PLANED FACES.

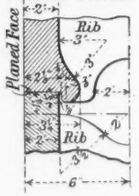


Fig. 20. TOP VIEW OF CENTRE CASTING.

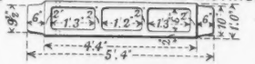


Fig. 24. SEC. C.C.

Fig. 23 END ELEV. B.B.

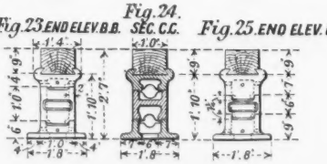


Fig. 25. END ELEV. D.D.

Fig. 21. TOP VIEW OF BOTTOM CASTING.

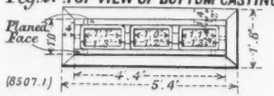


Fig. 27. REINFORCING OF FACE WALL.

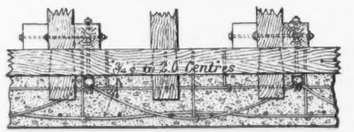
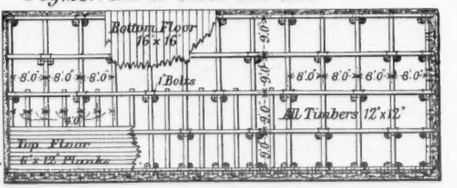


Fig. 28. PLAN OF OUTER END CRIB.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9

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Two-Page Plate.—THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, BRITISH COLUMBIA.

ENGINEERING.

FRIDAY, SEPTEMBER 26, 1924.

THE UTILISATION OF LIGHT ALLOYS.

IT is difficult for the engineer who is directly engaged in industry to keep in touch with the advances that are continually being made by the metallurgist. Until very recently the subject of metallurgy was rarely included in the curriculum of an engineering course, and even now it is doubtful if its importance is recognised sufficiently by engineering teachers. As a result of this neglect, comparatively few of the men who occupy responsible positions in engineering concerns possess the necessary groundwork of knowledge in this subject which would enable them to follow subsequent developments without great difficulty ; and, apart from this, the complex organisation of a modern works leaves the various members of the staff with but little time for academic study.

Comparative ignorance of metallurgy amongst the members of a works staff is relatively unimportant if the organisation is sufficiently large to permit of the inclusion of a trained metallurgist, but there are a very large number of firms engaged in engineering production in this country where such an inclusion could not be justified. In such cases the selection of the most suitable material for any particular part lies between the designer and the works staff, and it is in cases such as this that ignorance of the latest advances made in metallurgy is likely to be detrimental.

Dr. Aitchison, in a paper read recently before the Institution of Automobile Engineers, mentioned the comparative neglect of the newer alloys of aluminium and magnesium by the automobile industry in particular. Both he and Dr. Rosenhain, who recently spoke on the same subject at the Empire Mining and Metallurgical Congress, referred to the obvious use to which these alloys may be put in high-speed reciprocating elements, such as the pistons and connecting rods of internal-combustion engines. The materials which have been in universal use in the past for these elements have been cast iron for the pistons and mild steel for the rods, and, more recently, alloy steels have been suggested and largely utilised for the latter. For these materials to be replaced by aluminium alloys the latter must show an advantage as a whole, and not only in one particular.

All engineering work is a question of compromise, and in the case under consideration a large number of factors enter into the problem of the selection of the most suitable material. Amongst these may be mentioned cost, weight, strength, wearing qualities, conductivity, ease of manufacture and permanency, and all these have to be balanced in making a selection. In certain cases one of these factors may easily outweigh all the others ; for example, in engines where light weight or high speed is the ruling consideration, as in aero or racing engines, no hesitation will be necessary in selecting the aluminium or magnesium alloy, but the decision is much more difficult in the case of the normal commercial engine, which is designed to run at a moderate speed. It may be said at once that if the materials available were of equal cost the alloys would at once replace the cast iron or steel previously in use, because on most of the points mentioned there is little to choose between the old and the new materials, but the lower weight of the latter offers marked advantages. The out-of-balance force due to the inertia of the piston and connecting rod in even a small automobile engine is very considerable, and this force would be reduced approximately 60 per cent. by the substitution of one of the light alloys for cast iron.

The automobile trade is in a peculiar position in that the majority of the users of its products are not engineers, and rarely consider their purchases from an engineering standpoint. As a result, the designer, who has to satisfy such customers, has frequently to give undue weight to superficial considerations which may be no more than the whim of the moment, and receives no stimulus to embody features which would appeal particularly to trained engineers. Thus in the case of the ordinary touring car the customer will usually form his judgment of performance on the engine bore, which affects him directly from the point of view of the Treasury rating, and on the acceleration and maximum speed of the car. He has no conception of fuel economy in relation to total weight, and condemns a car if it is necessary to utilise his lower gear ratios on moderate gradients. To such a purchaser the question of engine balance is relatively unimportant, and he will frequently make quite erroneous condemnation based on nothing more important than some minor fitting being set in vibration, due to the defective design of that particular part. The vast majority of such people are quite satisfied with the degree of balance attained in an ordinary four-cylinder engine with cast-iron pistons, and would be quite incapable of appreciating the improvement in this respect which would result from fitting lighter rods and pistons. On the other hand, such people lay great stress on acceleration or "liveliness." The acceleration of an engine depends mainly on the power-weight ratio, and this can be increased in a variety of ways, of which the use of light materials for the reciprocating parts of the engine is only one. Others are the reduction of chassis or non-reciprocating engine weight, the alteration of engine stroke, and modifications in the design of the engine to reduce wire-drawing effects. Each method has its corresponding disadvantages as regards increase in cost, and the extent to which each is adopted is a question for the individual judgment of the designer.

Mr. Ricardo has pointed out that, besides the more obvious advantages of alloy pistons, their use eliminates the formation of carbon deposits on the underside of the piston, and also results in a lower oil consumption. Apart from the question of cost, their only appreciable disadvantage appears to be their greater coefficient of expansion. This results in piston slap when the engine is cool, owing to the greater clearance necessary, but as the piston reaches its working temperature very rapidly, this point is not serious. A factor on which further information is wanting is that to which Dr. Aitchison referred as smoothness of running in the cylinder. The remarkable surface which certain qualities of

cast iron acquire after prolonged friction between the piston and cylinder wall is well known, and it would be of greater interest to know whether an equivalent surface can be produced with a light alloy. Once such a surface is produced, the engine can be subjected to a certain amount of abuse due to shortage of oil or overheating without serious detriment, and if this can be shown to be a feature peculiar to the cast-iron piston, it is a point in its favour.

Broadly speaking, it may be said that the case in favour of alloy pistons has been made out more strongly than that for alloy connecting rods, though this may be in part due to the fact that the light alloy rod is a newer conception. At present there are certain disadvantages associated with the metalling of the big end of the rod. If the white metal is cast in, great precautions have to be taken not to overheat the rod, as this would seriously impair its subsequent strength. Although due attention may be given to this point in the first instance, there is little likelihood that equal care will be exercised by the repairer when the time comes for the renewal of the metal. The use of separate die castings would overcome this trouble, but as generally fitted they are more liable to fail owing to disintegration than the run-in metal. Possibly this would be overcome if the die castings were made somewhat heavier than usual, and if the whole rod was of light alloy, there would be no great objection to this on the grounds of increased weight.

In both the papers referred to, the correct treatment of the alloys in all stages of manufacture is emphasised, and there is obviously a better chance of this point receiving adequate attention if the parts are manufactured in large quantities. Unfortunately, it is still the usual practice of the British car manufacturer to produce the engine within his own works, which results in each manufacturer producing a relatively small number of special parts. This tendency is difficult to understand; but whether it is due to the inherent individuality of the British character, or to other causes, there is no doubt but that it is against the best interests of the automobile industry as a whole. It cannot be disputed seriously that one firm of specialists will produce a better and cheaper engine than a number of small firms all engaged upon almost duplicate operations, but in spite of this obvious fact a strong prejudice exists on the part of the public against the car with a component engine. It is apparently considered essential that certain components, such as the magneto and carburetter, should be purchased by the maker from a firm of specialists, but should a firm for any reason find it necessary to obtain their engine in the same manner, they are under the necessity of disguising it as their own product.

BRITISH MAIN LINE ELECTRIFICATION.

The question of main line electrification in this country has been the subject of much attention by various of our engineering institutions during the last few years, and that it is not going to be overlooked during the meetings of the coming session is made evident by the early appearance of a further paper by Lieut.-Colonel E. O'Brien. This was entitled "The Future of Main Line Electrification on British Railways," and was read before the Institution of Locomotive Engineers last night. That a very strong case for main-line electrification can be made is now a matter of common engineering knowledge, and, to those familiar with the subject, the paper did not perhaps contain much that was new. It was none the less of much value as bringing a close analysis of the subject before a new audience, and particularly a definite railway audience. It is well that from time to time this subject should be dealt with by the Institution of Electrical Engineers, but in the long run if anything practical is to be done, the matter must be dealt with by railway people, and anything which will tend to engender a proper appreciation of the arguments for and against such electrification in railway circles is to be welcomed.

Colonel O'Brien has more than once put the arguments for main-line electrification in a more definite and persuasive form than is perhaps usual in railway officials, and anything more which he can do to bring about a proper realisation of electrical possibilities in railway circles is likely to have the full support of all engineers. This is by no means a matter of interest only to electrical men. There is more mechanical than electrical engineering in a main-line electrification or in a power house, and a vigorous electrification policy would by no means run counter to the interests of mechanical engineering and the mechanical engineer. The matter has more than once been put forward as one of the items in unemployment relief schemes, and while there is no reason to dispute that electrification on a large scale would be of great value in absorbing labour, it would be very undesirable that the general public should get the impression that this is the main argument for such work. Electrification can make technical and commercial claims which require no bolstering by extraneous arguments.

As Colonel O'Brien began his paper by stating that main-line electrification in this country was not a remote possibility, but an immediate probability, it is not surprising that he was able to produce figures clearly showing heavy advantages in its favour. As we have said, the figures were not all new, but so important is it that a proper appreciation of the matter should become more general that a summary of his argument may well be given. To make his comparison between steam and electric operation as clear as possible, he divided it into two heads: first, the cost of energy, and, second, the cost of maintenance and operation. The cost of energy in the case of steam operation was taken as the cost of the coal delivered to the locomotive running-shed, and in the case of electric operation, as the cost of current delivered to the locomotive, including all costs of transmission and conversion.

As is very generally known, the results of British suburban electrification show that the cost of maintenance of electrical rolling-stock is less than that for analogous charges per engine-mile for the whole main line system of a steam-operated railway, although the service run by the electric stock is so much heavier. With main-line electrification this feature of the matter would show even more prominently in favour of electric working. Experience in many countries has also shown that an electric locomotive is capable of a very much greater annual mileage than a steam locomotive, and that its repair costs are only from one-third to one-seventh that of its steam rival. These factors are of such importance that Colonel O'Brien was able to show that, excluding the cost of fuel or electric energy, an economy of 10*d*. per engine-mile might be effected by substituting electric for steam locomotives. If this economy were not modified by other conditions, it would, if applied to the whole of the British Railways, represent no less a sum than 21,000,000*l*. annually.

Several matters would intervene in any efforts which might be made towards making this attractive saving, and, as Colonel O'Brien pointed out, one of them is the cost of siding electrification. The main factor, however, concerns the density of traffic. On this density depends the cost of electrical energy supplied to the electric locomotive, whereas the average cost of fuel for steam-operated services is practically constant whatever the traffic density. Making an analysis of the figures available, Colonel O'Brien showed that if current is purchased at 0·4*d*. per high-tension unit, the cost of current per engine-mile would never fall as low as the cost of coal per engine-mile at the running shed and would only approach it at the very high density of 8,000,000 trailing ton-miles per track-mile per annum. Other factors are such, however, that in Colonel O'Brien's opinion, if the cost of electrical energy could be reduced so that the cost of electricity per electric engine-mile was no higher than the cost of fuel per steam-engine mile, then the ultimate electrification of the majority of the British railway mileage would be assured.

At a traffic density of about 2,300,000 trailing ton-miles per annum the locomotive costs of operation by electricity are about the same as by steam. This density is, however, much exceeded on most of the heavily trafficked systems in Great Britain. Colonel O'Brien is of opinion that the density of the four track main lines radiating from London is at least 5,000,000 to 6,000,000 trailing ton-miles per track-mile per annum, and the consequent net increase in revenue per engine-mile for an area extending 150 miles from London would be at least 5*d*. per engine-mile. He went on to say that the cost of replacement of the steam locomotives by electric locomotives did not affect the question of capital expenditure as an electric locomotive could easily perform six times the mileage per annum of a steam locomotive, while the ratio of cost of an electric locomotive and a steam locomotive capable of equal duty was only 1·7 to 1. If the engine workings could therefore be arranged so as to provide only 1·7 times the annual mileage of the steam locomotive for the electric locomotive, the cost of the change should be borne by the renewal fund or from revenue without diminishing the net revenue of the railway.

THE MANUFACTURE OF THERMIONIC VALVES.

While the manufacture of thermionic valves for use in connection with wireless telegraphy and telephony has now been carried on in this country for several years, the comparatively recent introduction and the subsequent development of broadcasting, by creating an enormously increased demand for the valves, has had the effect of changing the manufacturing processes involved from the character of laboratory operations to the mass-production scale. The M.O. Valve Company, Limited, whose works at Brook Green, Hammersmith, we have recently had an opportunity of inspecting, is now producing some 25,000 valves a week, ranging from small receiving valves requiring only 60 milliamperes at 2·8 volts for heating the filament to large water-cooled transmitting valves capable of handling from 10 kw. to 20 kw. of electrical energy. All the processes involved in the production of these valves are carried on at the Brook Green Works, except the manufacture of the glass bulbs and tubing required, the bulbs being made at the Lemington-on-Tyne works of the General Electric Company, Limited, and the glass tubing at the latter company's works at Wembley, Middlesex, adjoining their Research Laboratory. The M.O. Valve Company, it should be explained, is a combination of the General Electric Company, Limited, and Marconi's Wireless Telegraph Company, Limited, for the manufacture of thermionic valves, which are sold jointly by the General Electric Company, Limited, and the Marconiphone Company, Limited.

One of the most interesting processes in valve manufacture is the production of the tungsten filaments, which, for the so-called bright-emitter valves, are similar to those used in metal-filament electric incandescent lamps. At the Brook Green Works, the scheelite ore, imported from Australia, is first ground in Braun planetary pulverisers, reduced by hydrochloric acid, precipitated, and dried into a low-grade oxide powder. This powder is further ground, mixed with water, and dried by heating in open pans, the product being the yellow powder of tungstic oxide. This is reduced at a temperature of 800 deg. C. in gas-fired furnaces through which a current of hydrogen is passed, a brown powder of a lower oxide being produced. Further heating of the brown powder at 900 deg. C. for two hours produces a grey metallic powder, which is sifted and pressed by hydraulic pressure into bars 8 in. in length and about $\frac{1}{4}$ in. square in section. These bars, which are quite brittle, are heated for 30 minutes in a tubular furnace and then "sintered" in an atmosphere of hydrogen by passing a current of 1,500 amperes through them. A coherent bar of metallic tungsten is produced in this way, which is afterwards gradually swaged down, with numerous intermediate heatings in gas-fired furnaces, to form fine rods 0·83 mm. in diameter. The rods are then drawn through gas-heated diamond dies, Aquadag being used as a lubricant, into wires for use as filaments, the finest of which has a diameter of only 0·0005 in. Dull-emitter filaments are produced in the same way, except that a very small percentage of thoria is added in the early stages. This has the effect of greatly increasing the emission of electrons for a given temperature, so that the valve operates satisfactorily with the filament at a dull-red heat. The current consumption is thus

greatly reduced and the life of the valve is correspondingly increased.

Apart from transmitting, rectifying and special valves, over 20 standard types of small valves suitable for broadcast reception are being produced at the works, mass-production manufacturing methods being naturally applied more particularly to the types for which there is the greatest demand. Many of the processes involved, we may mention, have emanated from the Wembley Research Laboratories of the General Electric Company, which were illustrated and described in our issue of March 2, 1923, on pages 256 and 275, and several of the automatic and semi-automatic machines employed for the work have also been designed and constructed there. The space at our disposal does not permit us to describe the construction and characteristics of all the valves made at these works, although we hope to deal with some of the recent developments in an early issue. It may, however, be of interest now to refer briefly to the design of the well-known R.5V. valve and to describe some of the manufacturing processes used, which differ only in detail from those employed in the production of the other ordinary types.

This valve is of the bright-emitter type, requiring a filament voltage of 5 and taking a filament current of 0·66 ampere. It will work satisfactorily with anode voltages ranging from 30 to 100, and is suitable for general reception purposes. The filament is in the form of a vertical triangular loop and the grid consists of nickel wire wound round a U-shaped support so as to form a flat cage. The anode, which surrounds the grid and filament, is in the form of a flattened cylinder and is made of thin nickel sheet. The supports for the grid, anode and filament are of stout nickel wire, to which is attached, by spot welding, a short piece of composite wire consisting of a nickel core with a copper coating, the combined coefficient of expansion of the two metals being practically equal to that of glass. This part, when sealed into the glass pinch, forms a gas-tight joint, and a length of copper wire, spot welded on to the other end of the composite wire, enables the electrical connections to be made. Four of these supports are required for each valve—one each for the grid and anode and two for the filament; an additional support, not electrically connected with the exterior, is provided to hold the upper end of the filament loop.

The four supports and leading-in wires for each valve are placed in the die block of an automatic machine, and over each set of them is placed a short length of glass tubing, flanged out at the upper end. The lower unflanged end is softened by blowpipe flames and afterwards pressed together by tongs to fix the wires in position and to form the pinch, which makes a gas-tight joint with the special composite wire. The anode and grid are made separately, the former from flat nickel sheet bent to the required shape and joined along the longitudinal seam by spot welding, which, it may be mentioned, is used exclusively for all internal joints and connections. The grids are produced in an automatic machine by winding fine nickel wire round U-shaped formers of stouter nickel wire, each turn being fixed in position by spot welding. The filaments, grids and anodes are then welded on to the supports, which have been mounted in the pinch as explained above, and when this has been done, a short length of magnesium wire is welded on to the exterior of the anode for a purpose which will be explained later. These operations are carried out successively by girls, who sit on the opposite sides of a bench and pass the parts, on small inclined conveyors, from one side of the bench to the other as each operation is completed. Jigs are, of course, employed to ensure the accurate assembly of each component, since the working characteristics of the valve are largely dependent upon the relative positions of the parts.

The bulbs, as supplied from the glass works, are without the familiar "pip" and are open at one end. The first stage in dealing with them is to burn a hole in the correct position by means of a fine blow-pipe flame, and to fuse in a short length of tubing to enable a connection to be made with the vacuum pump for exhaustion. This operation, known as "stemming," is carried on in an automatic machine. The electrodes mounted on the pinch, as explained above, are then sealed in to the open end of the bulb on another automatic machine, from which the valves are transferred to the pumping machine. This consists of a slowly rotating table provided with socket connections into which the stems are inserted. As the table rotates, the valves pass into a gas-heated oven, and, while still being heated in this way, the stems are put into connection first with a rough pump and then with a rotary pump, which produces a vacuum of about 0·001 mm. of mercury; in the same machine the stem is fused off. As one revolution of the table is completed, each valve passes under the electrodes of a Tesla coil, and the resulting glow discharge inside the bulb is an indication that the required degree of exhaustion has been attained. After removal from this machine, the pumped valves are fitted with a cap which is secured by shellac mixture, and finally with a composition base surrounded by a metal shield and carrying four pins to which the copper wires from the pinch are connected by soldering. The pins, of course, are spaced to fit into the usual socket.

The vacuum required in thermionic valves is considerably higher than that which suffices for an incandescent lamp, and, for the final exhaustion of the former, mercury-vapour diffusion pumps are commonly employed. For valves made on a quantity-production scale, such as that referred to above, the so-called "gettering" process is used for the final exhaustion. This process is carried out automatically on a rotating table, the otherwise completed valves being fitting into sockets on the table. As the table rotates, the filament is first heated up to a state of brilliant incandescence and a potential considerably above the normal working potential is applied to the anode. The comparatively heavy electronic current which then flows through the valve is sufficient to heat the anode to a dull red, so that the piece of magnesium attached to it, as mentioned above, is volatilised. Some of the finely divided magnesium combines with the small amount of gas left in the bulb, producing a very high vacuum, while the remainder is deposited in the form of a metallic mirror on the inner surface of the glass bulb. Here it serves the useful purpose of absorbing any further gas which may subsequently be liberated from the metal parts during the working life of the valve. For some valves, the heating of the anode during exhaustion and also for the purpose of volatilising the "getter," is effected by eddy currents, and in some other respects the manufacturing methods differ according to the type, size, and quantity being produced. In the case of dull-emitter valves, the filament is heated for some time to a definite temperature, which is considerably higher than is used in normal working, in order to bring a larger proportion of thorium to the surface, and the filament is afterwards "aged" by running it at its normal temperature for a long period. Valves of all types are thoroughly tested before being packed for despatch.

NOTES.

Amateur Wireless Transmission.

The subject of Dr. W. H. Eccles' address delivered on Wednesday last to the Radio Society of Great Britain, although only directly concerning the amateur wireless transmitter, is nevertheless of some general interest as an example of the manner in which the restrictions of a Government Department may interfere with scientific progress. In the past, it appears, British amateurs holding transmitting licences, in spite of numerous restrictions as to power, wave length, times of working, &c., have managed to communicate over great distances with almost incredibly low powers, and, as an example of the utility of their work, Dr. Eccles pointed out that the commercial use of short waves for long-distance transmission has been the outcome of attention directed to the matter by the results of amateur experiments. Recently, however, a further important restriction has been imposed by the Post Office on the activities of amateur transmitters, who are now only permitted to transmit messages to stations in Great Britain and Northern Ireland which are actually co-operating in the transmitter's experiments. Although, we believe, special permission would be granted for British amateurs to carry out particular experiments with foreign amateur stations, the new regulations would appear seriously to hamper international co-operation in wireless experiments and to place the British amateur at a disadvantage, in comparison with the foreigner, with respect to long-distance working. It certainly seems highly improbable that the amateurs of this country would have been able to demonstrate the possibilities of short waves had the new restriction been in force two or three years ago. Dr. Eccles, after explaining the provisions of the Wireless Telegraphy Act, discussed some of the existing anomalies in connection with the granting of amateur transmitting licences by the Postmaster-General, taking particular exception to the interpretation of one of the provisions of the Act, to compel applicants for licences completely to disclose the objects and methods of their proposed experiments. Experimental methods, he pointed out, could rarely be foreseen, being usually evolved as the experiments proceed, so that to insist upon a statement of the methods to be adopted before the experiments can be commenced may deprive some competent experimenters of the opportunity of doing really useful work. The remedy, Dr. Eccles suggested, was to revise the existing regulations in the light of the experience of other progressive countries, so as to give British amateur transmitters equal freedom, and, of course, equal responsibilities, to those of their fellow-workers in the United States, France, and elsewhere.

Port Facilities for Vessels of Deep Draught.

The question of the ultimate draught of large vessels has come up at innumerable conferences, and in a general way remains undecided. It is accepted that deeper draught, permitting of larger capacity, is an economical direction for development up to some rather indefinite figure. This figure depends upon the nature of the trade engaged in, the lost time waiting for full cargoes, and the costs of working part-time partly loaded. When a concrete case is taken the problem is a little less abstruse and a policy may be determined with more nicety, though still based, perforce, on assumptions which time in these days of quick changes may early prove at fault. A definite case has recently arisen in connection with Colombo Harbour. This is a port of call on important routes, not only as a centre of trade, but also for bunkering purposes. A Suez Canal programme contemplates the deepening of that waterway by 1933 or 1935 to allow of the passage of vessels of 36 ft. draught. The Panama Canal permits of the passage of ships drawing 36 ft. or slightly more, and the lock construction practically precludes deepening. At Colombo, work is in hand to provide for the accommodation at moorings of vessels drawing 33 ft., one such berth being now available. This requires a depth of water of 36 ft., and to go deeper than this would entail a great deal of costly excavation in rock. The Imperial Shipping Committee, on being approached for advice in the matter, have recently obtained the views of shipping companies trading on the route. The Holt Line and the Glen Line at present run the steamers with the greatest draught to this port. The Holt Line does not contemplate the use of vessels drawing more than their present extreme draught of 33 ft. 10 in. in the next few years, and does not think the port should be deepened for the very occasional need of deeper berthage. The chairman of the Glen Line considered that the deepening of the harbour should keep pace with the Suez Canal. Deeper draught vessels are hardly anticipated in the Australian trade. The committee report that, as the cost of the additional excavation would necessarily increase harbour dues, the effect might quite likely prove unfavourable to the port, especially since the development of the oil engine may make it possible to cut out ports mainly used on certain routes for bunkering. If the survey of the harbour should prove the work of deepening to be very costly, the committee consider that there would not be at present sufficient justification for undertaking it.

Street Lighting.

The lighting of public thoroughfares involves the consideration of problems so entirely different

from those encountered in the internal illumination of ordinary buildings that it has been thought advisable to form a special institution to deal with the questions. This body, the Institution of Public Lighting Engineers and Superintendents, held its first conference in The Royal Technical College, Glasgow, from September 16 to 18, under the chairmanship of Mr. S. B. Langlands. In the course of his presidential address Mr. Langlands described the arrangements made to deal with the lighting of streets and the passages and stairs providing access to flats in Glasgow. In the busiest thoroughfares an endeavour was made, he said, to have a mean effective value of illumination of about 2 candle feet. This had been obtained by arrangements which gave a maximum illumination of about 5 candle feet and a minimum of 0·1 candle feet. Smaller values were in use in streets with less traffic and in the stair lighting a lamp which gave about 20 candle power had been installed at every lighting point, but increased values were used where the stairs were badly constructed and exceptionally dark. Both the electrical and the gas fittings used for the purpose of public lighting had been standardised. In Glasgow the public lighting department was entirely independent of both the electricity and the gas undertakings, and consequently the aim had always been to get the best possible results with either illuminant under all the varied conditions. In his paper on "Electric Mains for Street Lighting," Mr. R. B. Mitchell, Electrical Engineer to the City of Glasgow, detailed the requirements, specified many of the problems involved and showed how they could be economically solved. Mr. Haydn T. Harrison, in presenting a paper on "Projected Light," discussed the lighting of highways for motorists and referred to experiments made with fixed lights at small heights above the road. He claimed that many of the disagreeable features to pedestrians of this system of lighting had now been overcome and that powerful lamps could be used, if they were put below the eye level and shielded from direct sight by a system of louvres. Another paper concerned the subject of "Street Lighting and Visibility." This was read by Mr. Edward J. Stewart, of the Glasgow Corporation Lighting Department, who referred to the subject as being surrounded by conflicting issues. Compromise was necessary if they were to obtain the desired street illumination at low cost, to keep down the number of standards, to get good distribution and diffusion and to prevent glare, although high candle powers were used.

THE NAVY AT THE BRITISH EMPIRE EXHIBITION.—V.

Messrs. Yarrow's exhibit is a little difficult to locate, being in a different portion of the Palace of Engineering from the majority of the engineers and shipbuilders. It will be found on the right-hand side on entering the Stephenson Gate. Many interesting models are exhibited by the firm, and the largest of these is one of the latest type of the famous Yarrow boiler.

Those familiar with the evolution of the torpedo-boat destroyer will remember that after the marked success of the first six of the type ordered in 1892, and of which Messrs. Yarrow built the Boxer and Bruiser, a large number of vessels of the type were ordered by the British Admiralty, and the contracts were divided between over a dozen firms. Requirements as to speed, load on trial, and other vital details were communicated to the firms, and they were invited to forward their own designs of hull and propelling installations. A different type of water-tube boiler was suggested by each firm, and since the object was to ascertain the most efficient boiler for the purpose, each was allowed to instal the type proposed. Some of these boilers were of very complicated design, and experience at sea with the completed vessels soon indicated the advantages and defects of the various types. In later classes of destroyers the number of types of boilers gradually diminished, until, at the present time, only two remain, of which the Yarrow type is one.

So far as the larger types of warships were concerned, it was the practice after the introduction of water-tube boilers to fit only those of large tube type, such as the Belleville. This continued for some time, until the demands for increased power and speed necessitated the fitting of the lightest and most efficient type of boiler. As a result the Yarrow boiler is now found in all sizes and types of warships of the British and many foreign navies—a striking example of the "survival of the fittest." During the war, 90 per cent. of the warships built in Great Britain were fitted with Yarrow boilers,

THE NAVY AT THE BRITISH EMPIRE EXHIBITION.

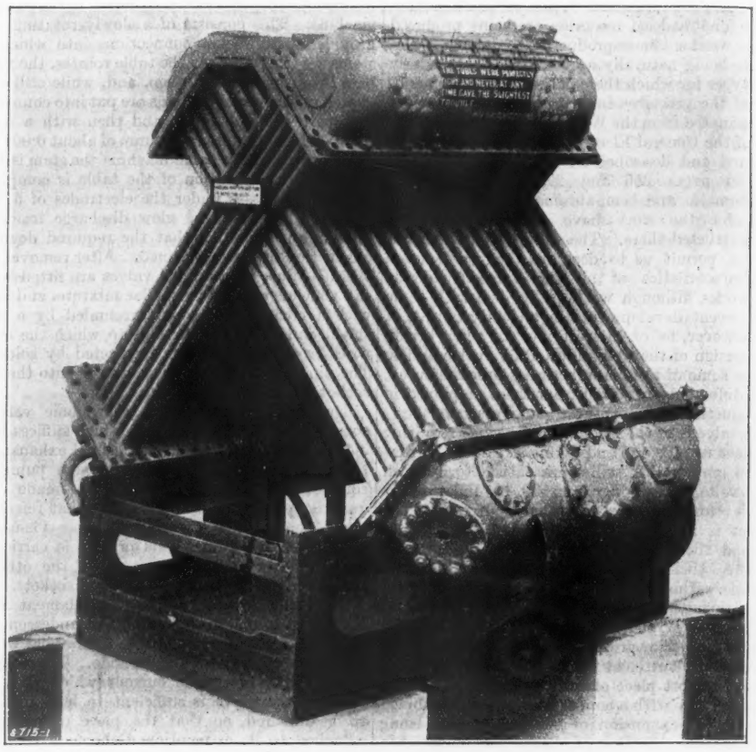


Fig. 28. Early Type of Yarrow Water-Tube Boiler.

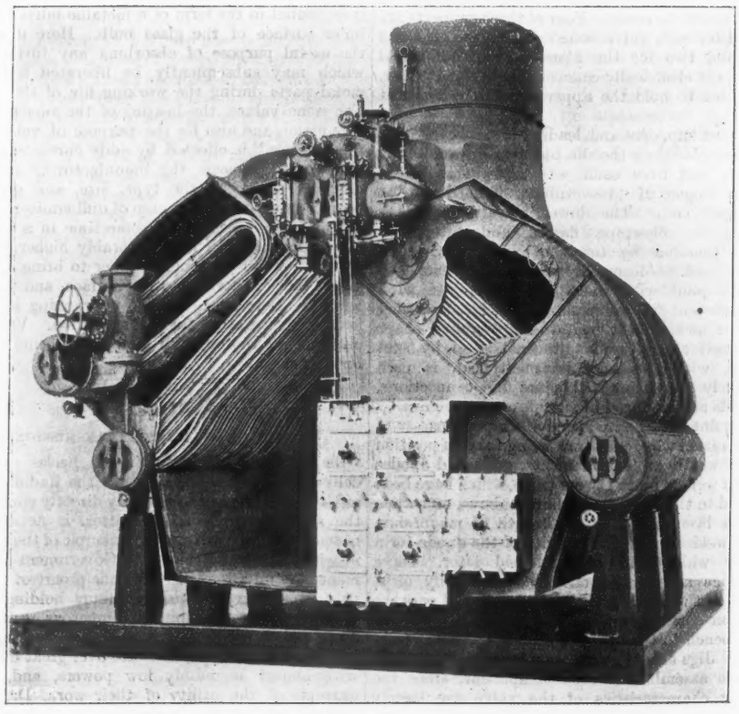


Fig. 29. Modern Yarrow Boiler with Superheater for H.M. Destroyer "Tyrian."

THE NAVY AT THE BRITISH EMPIRE EXHIBITION.

FIG. 30. HULL OF SHALLOW-DRAUGHT VESSEL WITH YARROW HINGED FLAP.

and, up to date, the boilers of this type which have been constructed or are now in hand represent no less than 25,000,000 h.p.

Sir Alfred Yarrow introduced his boiler in 1885, and one of the first to be constructed is on view. It is a small boiler standing about 5 ft. high, but, as will be seen from Fig. 28, on the opposite page, it is of different design from the form which is now so familiar. The tubes are straight as at present, but in place of a single steam drum of circular section as now fitted, it has two of semi-circular section, the flat portion of each forming the tube plate. The two water drums at the bottom are of the same section as the steam drums, the tubes from one water drum all crossing to the steam drum on the opposite side. Experience, both in construction and use at sea, showed in what direction improvement could be effected, and later the boiler took the form which it retained for many years, *i.e.*, a single cylindrical steam drum connected direct by straight tubes with two cylindrical water drums of smaller diameter symmetrically placed at the base.

The firm has always been intensely progressive, endeavouring to improve upon their previous best, generally with success. Superheaters have been added to the boiler, and the form which was adopted in the boilers of the Tyrian, one of the latest destroyers built by the firm, is shown in Fig. 29, the superheater being clearly indicated on the left-hand side. After fitting so many warships with their boilers, Messrs. Yarrow are now supplying them to land installations, and a model at the stand shows the form adopted (see page 177 *ante*). In this type, one water drum is fitted on one side and two water drums on the other, with superheater between. Economisers at the level of the steam drum, on both sides of it, and air-heaters in the uptakes are also important features.

Messrs. Yarrow also show a model of a destroyer which was completed to their own design in December, 1919, the last of a batch of seven of the same class of which the first was commissioned in May, 1918. These vessels are included in a class of destroyers, of which 70 were built. Their designed speed was 36 knots, displacement about 1,075 tons, length 276 ft., and shaft horse-power of turbines 27,000. The Tyrian and her sister vessels are of 930 tons displacement, length 273½ ft. and shaft horse-power of engines 23,000. The Tyrian attained a speed of 40 knots, and her sister vessel, the Torch, 39¼ knots. The armament, both gun and torpedo, is the same in all vessels of the class. Thirty-two destroyers were ordered from Messrs. Yarrow during war and of these 28 were completed, the others being cancelled after the armistice. Messrs. Yarrow were one of the pioneer firms in the construction of fast torpedo craft, and have designed and built a great many torpedo boats and destroyers for foreign navies, in addition to a large number for the British Navy. There has always existed a friendly and healthy rivalry between Messrs. Thornycroft and Yarrow for speed, and a ding-dong race has resulted. The two firms have recently each received an order from the British Admiralty for a destroyer, and the particulars of these vessels and their trial results will be awaited with interest.

Another type of vessel in which Messrs. Yarrow have specialised and of which they have designed and constructed many successful examples is the light-draught river steamer. Those who have read Lady Yarrow's book on the life-work of her husband will be familiar with the details of the first of the type built by him for service on the African lakes. The Herald and Mosquito, stern-wheeler gunboats built for the British Admiralty for service on the Niger, were two early examples, and these were followed by others of larger and improved type with twin screws for service on the Nile, with Kitchener, on the Yangtze, Tigris, and the Danube. The Robin, one of a small fleet of six shallow-draught gunboats built for service in China in 1898 by Messrs. Yarrow, is still in service. This vessel, of 85 tons displacement, is 108 ft. long, 24 ft. broad and of 2 ft. draught, has a speed of 9 knots and is armed with two 6-pdr. guns. Two larger vessels, the Teal and Moorhen, were built in 1901 and displace 180 tons, having a speed of 13 knots and carrying two 6-pdr. and four machine guns. The Widgeon, of the same class, was completed in 1904.

Early in the war, the naval authorities decided that vessels of this description would be eminently suitable for service in certain theatres of the war, and Messrs. Yarrow were requested to design and construct two classes which were designated small and large "China" gunboats. The former were intended for use on the Tigris, and the latter on the Danube. The firm completed both designs, being given a free hand by the Admiralty, but the great pressure of work on other classes of war vessels prevented them building the larger gunboats, and the orders for these were given to firms who were not so pressed. Twelve of the smaller gunboats were, however, built and completed by Messrs. Yarrow. The order was placed on February 9, 1915, and four were completed ready for shipment to Abadan, near Basra, in July of that year. The first vessel was erected and commissioned in November, 1915, and the remainder followed soon after. When it is stated that the slips at Abadan, on which the erection took place, had to be improvised and that other facilities were limited, the record in the construction of these vessels is a remarkable one. These gunboats were 126 ft. in length, 20 ft. beam and 2 ft. draught, displacing 100 tons, fitted with one Yarrow boiler, reciprocating engines and one screw, the horse-power being 175 and the speed 9½ knots. The armament included one 4-in., one 12- and one 6-pounder, one 3-pounder high-angle, one 2-pounder pom-pom gun, and four maxims. One, the Firefly, was captured by the Turks, but was recaptured later and all took a prominent part in the advance on Baghdad. Shortly after the capture of the Firefly, four more were ordered.

The larger class, of which 12 were built, were 238 ft. long, 36 ft. beam and 4 ft. draught, displacing 640 tons. The engines were of 2,000 i.h.p.; two screws were fitted and a speed of 14 knots attained. The armament was a relatively heavy one, and included two 6-in., one 3-in. high-angle and two 3-pdr. guns. Some of these boats were sent to the Persian Gulf, and although such a type of vessel is not intended for oversea navigation, they, after being temporarily stiffened, were towed to their destination without serious damage. A model of this larger class is exhibited. The firm also designed and built a repair ship for the Tigris fleet. Named the Scotstoun, she was a stern wheeler and was stationed at Abadan and proved very useful.

A working model is also exhibited which fully demonstrates the principle of the "hinged flap" devised by Messrs. Yarrow and fitted abaft the propellers in shallow-draught steamers. It was first fitted in the gunboat Widgeon and proved so useful that it has been adopted in all gunboats since built by Messrs. Yarrow. The small draught —2 ft.—specified in earlier vessels limited the diameter of the propellers which were each housed in a recess in the bottom plating. The recess had a maximum height at the propeller and inclined downwards, forward and aft. The plating on the crown of the portion of the recess abaft the screw introduced a serious resistance to propulsion, which, for the same speed, was constant at all draughts, light or deep. The hinged flap was introduced to diminish the resistance at the deeper draughts. To permit of the flap being fitted, the recess abaft the propeller is made rectangular in section, the crown being flat and horizontal. The flap is hinged to the crown near the propeller, and its after end can be raised or lowered from the deck as necessary. When in the desired position, the after end of the flap is just immersed in the water. When the propeller revolves, the recess is filled and the screw works in solid water. At deep draughts, the flap is less inclined than when the vessel is light and its resistance to motion ahead is reduced. With this arrangement, the propeller shaft can be fitted above the light water-line and the propeller made of larger diameter than with the fixed type of recess. A bolted watertight portable plate on the top of the recess over the propeller allows of the latter being inspected or repaired. The device has proved very successful and has been adopted in many types of shallow draught vessels built by Messrs. Yarrow. Fig. 30, on this page, shows the hull of a shallow-draught vessel pitch with the device.

A model of a yacht—the Cutty Sark—built by the firm on destroyer lines is also on view. With a length of 273 ft. and a beam of 25½ ft. she attained a speed of 22 knots.

Two other exhibits remain to be noticed before

concluding, viz., Messrs. Simons, Renfrew, and Swan, Hunter and Wigham Richardson. The former firm specialise in dredging vessels, a type of craft which is necessary for the maintenance of naval harbours and bases. Many models of dredgers, both of the bucket and suction type, are on view.* Another model shows the arrangement of two hospital ships built during the war for service in Mesopotamia and designed by Sir John Biles. These are shallow-draught vessels, driven by paddle-wheels placed amidships. A type of war vessel which has not been noticed in other exhibits is the "sloop." A model of the Lupin, one of this type, is shown by Messrs. Simons, and is representative of half-a-dozen built by the firm. These vessels were primarily intended for mine-sweeping and were fitted with the necessary gear—gallows, wires, winches, &c.—for this dangerous and important work. They performed other useful functions, and some are now engaged on police and other work in distant seas. Many have been sold and reconditioned for commercial work. Over 100 were built during the war, the dimensions of the majority being 255 ft. long, beam 33½ ft. and draught 11 ft. They displaced 1,250 tons, and were fitted with two tank boilers, triple-expansion engines of 2,000 i.h.p. and twin screws, giving over 17 knots. They had two 4·7-in. and two 3-pdr. guns.

Messrs. Simons also exhibit a model of the Confiance, a 36-gun frigate built by the firm in 1812. A comparison of her features with those of the modern warships in the neighbouring exhibits will impress the most casual visitor with the tremendous differences between the ships which sailed with Nelson and those which served with Beatty. The more thoughtful will be tempted to speculate on the differences which are likely to be observed in the models of warships exhibited in the next great Empire Exhibition, and those which now so well represent ships of the British Navy at Wembley.

Messrs. Swan, Hunter and Wigham Richardson, Limited, exhibit a large number of ship models which admirably represent the various types of vessels that have been launched from their slipways on the north bank of the Tyne. Amongst these models is one of the Mauretania, the largest mercantile vessel built at Newcastle, which has very recently broken three speed records for the eastbound Atlantic passage. The light cruiser Comus and the destroyer Laertes are also represented. The former was completed in May, 1915, and is of the Caroline class already referred to. A later and larger cruiser, the Coventry, of the Ceres class, was completed by the firm in February, 1918. The Laertes was a destroyer completed in 1913, having a displacement of about 1,000 tons and fitted with engines developing 22,500 shaft horse-power to give a designed speed of 29 knots. On trial, 25,000 shaft horse-power was developed, giving a speed of nearly 32 knots. Four sister vessels—the Shark, Sparrowhawk, Spitfire and Lysander—were also built by the firm. A model of the Radstock is in the Government Pavilion, and is representative of some 25 destroyers completed by the firm and engined by the Wallsend Slipway and Engineering Company during the war. Several submarines and sloops were also constructed and many units repaired.

One type of naval construction in which Messrs. Swan, Hunter and Wigham Richardson have particularly specialised, and for the building of which their works are very adequately equipped, is represented by a model of the Bermuda floating dock completed for the British Admiralty in 1902, and which, after trials in the Medway, was towed across the Atlantic. The lifting capacity of this dock is 17,000 tons, and it is built in sections each of which can be unbolted from the main structure and docked upon the remainder for inspection, repair or repainting. Altogether the firm have constructed 32 floating docks of various types, the aggregate lifting power being 180,000 tons. The largest was completed for the Admiralty in 1912 and has a lifting capacity of 33,000 tons. The side walls of the dock contains stores, workshops, machinery, and all necessary appliances for ship and engine repair, together with accommodation for workmen and crew of the docked vessel, and is thus a complete unit. The great size of the dock—it is 690 ft. long and 160 ft. wide—necessitated it being of the solid type, *i.e.*, it is a completely riveted structure and is not in detachable sections. It was intended originally for the Medway, and on completion was towed there and moored in the position prepared for it. Shortly after the outbreak of war the naval authorities found it necessary to increase and improve the docking facilities on the north-east coast, to enable the larger units of the Grand Fleet to dock as close as possible to their bases. The Medway dock was towed to the Tyne and berthed in Jarrow Slake—not far from the slipway on which it was built—where it proved extremely useful, not only for the periodical dockings of the larger war vessels, but also for their repair after action. After the armistice, it was transferred to a southern naval base. The sister dock built by Messrs. Cammell Laird was similarly towed from Portsmouth to Invergordon, where it remained throughout the war. It was very fortunate for the Allied Grand Fleet that these two docks were available at the required positions during the war, and the rapid, easy, and safe transference from one position to another, as required by the exigencies of naval strategy, emphasised one great advantage of the floating dock over the fixed or masonry type.

* See ENGINEERING, vol. cxvii, page 548.

FIG. 31.

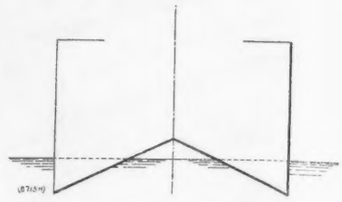


FIG. 32.

FIGS. 31 AND 32. MOTOR SEASLED; MESSRS. SWAN, HUNTER AND WIGHAM RICHARDSON, LTD.

Messrs. Swan, Hunter and Wigham Richardson have also on view a full-size example of a type of boat construction which, at present, is in greater evidence on American waters than on those of the British Isles. It is termed a "seasled," and, it is stated, is carried on the majority of American warships, having superseded the ordinary type of steam and motor boats hitherto carried. The seasled, which is illustrated in Figs. 31 and 32 above differs in many important respects from the ordinary shape of boat, and also from the stepped-bottom type represented by the coastal motor-boat. In plan it is rectangular, in section it has vertical sides from chine to gunwale, but from chine to chine its shape is that of an inverted and flattened V, the keel being thus higher than the chines and above the waterline when at rest (see Fig. 32). The bow is scow-shaped in profile, but in front view is bifurcated, the recess of the bottom being continued along the scow end. At the stern it has a vertical transom.

Twin-plate rudders are fitted, the front edges being hinged to the sides of the boat, the after ends of the chines being shaped away to allow the rudders to rotate, but without projecting beyond the transom. The two rudders are connected by a rod and moved together by the tiller or steering wheel. The engine is fitted direct to the propeller shaft, the latter passing through the transom and being above the water-line when the boat is at rest. The propeller is thus half-immersed when at rest, and although this appears a disadvantage as compared with the completely submerged screw, it is claimed by the patentees that the shaft and shaft-bracket resistance is eliminated, and much superior speed results are obtained than in ordinary motor-boats with the same power per unit of displacement. Other advantages are that there is less likelihood of damage to the hull if the propeller strikes floating objects, and the propeller can be unshipped and replaced or refitted with the boat afloat. It is also claimed that, in this type of craft, more passengers can be accommodated; the shape of transverse section adopted gives greater stability when in still water or in a seaway; there is far less water disturbance and spray thrown up when moving at high speeds; and the air-cushion which is formed under the keel eliminates nearly all "pounding" when in a seaway, often obvious in ordinary high-speed motor boats. An American boat—Orlo III—built on these lines, attained a speed of nearly 58 m.p.h. on a mile run, and 40 m.p.h. on a 50-mile course. The boat, which is on view at Messrs. Swan, Hunter and Wigham Richardson's stand, is a "runabout" with a length of 24 ft. and is fitted with an engine of 35 h.p., which gives a speed of 18 m.p.h. It is a handsome craft, and possibly, now that this firm has taken this type of construction in hand, it will become popular on British waters. The builders are Messrs. Philip, of Dartmouth, an associated firm of the Tyneside shipbuilders.

REFRACTORY SECTION OF THE CERAMIC SOCIETY.

The Refractory Materials Section of the Ceramic Society held its fourteenth meeting on the 18th and 19th inst., the gathering of members taking place at the British Empire Exhibition, Wembley, under the chairmanship of Mr. J. Holland. There was a good attendance, though for various reasons several familiar figures were not in evidence.

A COMPARISON OF GAS AND COKE-FIRED DRYING STOVES.

The first paper on the above subject was by Mr. T. W. Barley. For some years, he said, the cost of drying moulds and cores has been a subject of close attention at the Imperial Steelworks of Edgar Allen and Co., Limited, Sheffield. Day by day many moulds and cores have had to be dried between 5 p.m. and 8 a.m. It was formerly the practice to place the cores on bogies placed in brick chambers, these chambers being provided with fire-boxes at the end farthest from the door. Coke was used as fuel, and some of the moulds were spoiled by overheating, whilst others were insufficiently dried during the run. Such a stove, having a capacity of only 710 cub. ft., required no less than 17 cwt. of coke in 14 hours.

In 1911 the foundry was re-built, and with a view to making better use of the space and at the same time increasing the efficiency of the drying process, it was decided to lay down drying chambers to be operated by Sheffield town gas, which was then only 10*d.* per 1,000 cub. ft. and of about 560 B.Th.U. The consideration that the absence of furnaces and chimneys, the consequent simplification of the construction of the drying chambers, the elimination of carting (fuel and ashes), and the smaller number of operators required, along with the low price and good quality of the gas, might even result in a reduction of drying costs was actually realised. Unfortunately, the outbreak of war soon afterwards exercised an adverse influence, but during the war they performed their work, and the fact that they could be operated with a minimum amount of labour was then a consideration of primary importance.

Post-war conditions made it necessary to give close attention to the drying problem. In 1915, the 76,615,500 cub. ft. of gas used for drying cost 3,939*l.*, whilst in 1920 the 53,619,900 cub. ft. of gas used for drying cost 9,691*l.* The gas burners used were of standard Bunsen type. Careful investigations showed that regulation of the gas pressure was very desirable, that the temperature in the drying chamber ranged from that of the atmosphere to a maximum of 385 deg. C., and from 385 deg. at the roof to 100 deg. C. at the top of the carriage supporting the moulds and cores. Results of research in the laboratory showed the importance of drying at a lower temperature in order to reduce the risk of breaking down the natural bond of the sand. In connection with the stoves heated by means of Bunsen burners, it was found that a slight increase of pressure produced a slight increase of temperature, but was associated with a proportionately much greater consumption of gas, that whatever the temperature of the stove might be the reading of a thermometer buried in a core or mould never exceeded

100 deg. C., and that much condensation of moisture took place within the stove, causing rust to form on the metal surfaces. By regulation of gas pressure and temperature a saving in each stove of 2,250 cub. ft. of gas per run was made. Insulation by a lining of Moler bricks saved 2,000 cub. ft. of gas per run of 15 hours, and reduced the time required to attain a drying heat. By these two means the consumption was reduced from 25,250 cub. ft. to 21,000 cub. ft. of gas.

With a view to improving the temperature gradient a new burner was tried instead of the Bunsen burners. The apparatus consists essentially of a special gas and air-mixing chamber (Fuller burner), a Keith Blackman air-pressure fan working at 8-in. water gauge, and two 4-in. steel tubes arranged down each side of the drying chamber and provided with outlets to point towards the centre line of the chamber. In working, gas is passed through the mixing chamber and ignited, the secondary air being then turned on, the effect being to project a flame down the entire length of pipe—some 20 ft. or 22 ft. Next to the mixing chamber a short fireclay sieve is inserted in the pipe as a protection from the intense heat of the flame at this point. This installation has been operating six days per week since the end of June, 1922, the gas consumption averaging 1,000 cub. ft. per hour. Since it was got into working order no further trouble has arisen. The operating time has been reduced by one hour and the gas consumption by more than 5,000 cub. ft. per run as compared with the Bunsen burners. The cost of working the fan is 1*s.*, and the only cost for repairs was a small sum for renewing the fan impeller. The temperature gradient within the drying chamber has been very materially reduced, and the maximum roof temperature has been brought down from 385 deg. C. to 225 deg. C. Another pressure-gas installation was tried, made by the British Furnaces, Limited. The essential difference between this and the Fuller system is that a higher air pressure is used and a much higher temperature is attained at the point of combustion, but the results are very similar from the two installations. The condensation taking place within the drying stove was considered to be an adverse factor from the moulders' point of view, so no further development was attempted with these gas installations.

The conventional way to dry clay crucible pots used for the production of special alloy steels is to construct the drying chamber over the flue leading from the coke furnace to the chimney. This process is wasteful in fuel, and also creates a considerable temperature gradient in the drying chamber, resulting in a large percentage of wasters. Eventually a high pressure hot-water or Perkins system was tried with complete success, the coke consumption being halved and wasters practically eliminated. A similar drying stove for cores was fitted up in the foundry, but, though it satisfactorily dried plain sand cores, it was not successful with oil sand cores, which came into extensive use then, and so it was abandoned. It was not possible to get a higher temperature than 110 deg. C. in the drying stove, and oil sand cores should be stoved at not less than 180 deg. to ensure expulsion of the volatile constituents of the oil.

It was realised that the ideal stove should have as the drying medium hot gases, or air as dry as possible, and at as constant temperature as possible, and also that ventilation of the drying chamber is a most important factor. As it is a costly business to heat up large quantities of air, this line of investigation was reluctantly abandoned.

A Hüttenes coke-fired, air-blown furnace was next imported from Germany. The furnace itself is a steel plate box, lined with firebricks, divided into a combustion chamber with firebars and feeding door at the top. The fuel used is low-grade coke, breeze, lignite, or any other cheap fuel. The hot gases pass over a bridge at one end of the furnace, down each side of vanes or louvres of firebrick, between which they are met by a compressed air jet at 80 lb. pressure per square inch. The products of combustion are thus projected into the drying chamber at a high velocity, and at the same time the draught through the firebars is increased materially. The furnace was attached to one of the drying chambers, and a trial run gave most satisfactory results. In order to adapt the furnace better to the requirements of mould and core drying in chambers, a brick furnace is now constructed, in most cases sunk into the ground. The hot gases are directed upward instead of downward, and a number of drying chambers are operated from one furnace, using as many compressed air jets as drying chambers, the compressed air being also pre-heated. The advantages attending the use of this type of furnace in the way indicated include economical fuel consumption, small first cost and low cost of maintenance, economy of space and absence of chimney, little attention required during the run, easy regulation of temperature (within limits) by turning on more or less air, the possibility of placing it at some distance from the drying chamber with little loss of heat, and reduction of labour and of cost of construction by making one furnace serve a number of drying chambers. Guidance may be given to the operator (who may be unskilled) by a satisfactory thermographical chart while other advantages are the possibility of using the cheapest available fuel above the grade of dust (cinders from the Sheffield Corporation Cleansing Department collected with the household refuse are used, costing 6*s.* 6*d.* per ton), the attainment of complete combustion, and the possibility of giving the chamber an equable temperature throughout or any desired temperature gradient within limits.

The performance of these furnaces during the past ten months support the claims made for them. An average load (of moulds and cores) on the carriage would be 30 tons to 35 tons. All the moulds are thoroughly dried at the end of the run, no moulds being found either burned or imperfectly dried.

The average working temperature employed for mould-drying stoves is 225 deg. C., and 7 cwt. of coke are used per run of 15 hours. For large core stoves the average working temperature is 200 deg. C., using 4½ cwt. of coke, and for small core stoves the temperature is 180 deg. C., using 4 cwt. of coke. The height of the stove is very important, efficiency being increased by lowering the roof so long as it serves its purpose. Experience has shown advantage in having stoves for drying cores not so high as those for mould drying.

The air is supplied by the foundry air-compressor plant, which consists of two electrically-driven Belliss and Morcom high-speed two-stage compressors, of 150 cub. ft. free air capacity. The nett amount of current consumed in a run of six hours was found to be 22 units, the nett cost for current only being 1*s.* 7½*d.* per run of six hours.

On August 18 last the average temperature in one of the drying chambers was found to be 190 deg. C. in the centre of the chamber, 6 in. below the roof, practically the same reading being obtained at the end next the furnace (burning coke breeze) at a point midway from the carriage floor to the roof. A reading on top of the carriage, next to the outer door, gave an average of 150 deg. C. The temperature of the products of combustion between the louvres and just inside the drying chamber ranged from 920 deg. C. to 740 deg. C. during two hours. Air pressure was maintained at 80 lb., which has been found to be the most efficient pressure. The ventilation outlets were set to give a total of 48 sq. in. area, also previously found to be the best.

Samples of the products of combustion taken simultaneously before and after admixture with compressed air gave on analysis, the following results :—

Before Admixture with Compressed Air.		After Admixture with Compressed Air.	
CO_2	13·15 per cent.	CO_2	13·96 per cent.
O_2	Nil	O_2	5·23 ,,
CO	12·85 per cent.	CO	0·41 ,,

Mr. W. J. Rees said he could corroborate all Mr. Barley's figures from personal observation. He threw out the suggestion that in the first stages of kiln firing, hot gases might be applied in order to avoid the condensation associated with slow fires.

Mr. Barley intimated that anyone interested might see the drying stoves in work at Messrs. Edgar Allen's works at Sheffield.

Some Properties of Clay-Sillimanite Mixtures.

The next paper, by Mr. H. S. Houldsworth, M.Sc., on the above subject, was, in his absence, read by Mr. Dale.

The object of the work was to study the changes in physical and chemical properties of a clay when mixed with varying percentages of sillimanite. The natural commercial sillimanite used contained 32·9 per cent. silica and 64 per cent. alumina with ferric and titanic oxides. The grading was as follows :—

					Per cent.
Through 5–mesh	retained on	10	mesh in	....	11·8
,, 10	,, ,,	20	,,	....	6·2
,, 20	,, ,,	30	,,	....	17·5
,, 30	,, ,,	50	,,	....	21·4
,, 50	,, ,,	60	,,	....	6·8
,, 60	,, ,,	80	,,	....	5·9
,, 80	,, ,,	100	,,	....	2·4
,, 100	,, ,,	120	,,	....	2·9
,, 120	,, ,,	150	,,	....	4·2
,, 150	,, ,,	200	,,	....	2·9

with 18 per cent. through 200 mesh.

Test pieces were made from Farnley fireclay alone and from mixtures containing 20, 33⅓, 50, and 66⅔ per cent., respectively, of sillimanite, and also of mixtures containing 95 per cent. sillimanite with 5 per cent. ball clay, and 90 per cent. sillimanite with 10 per cent. ball clay, the clays being first ground to pass a 20 mesh standard sieve. The test pieces were fired in a works kiln to cone 06 in 48 hours and to cone 9 in 72 hours, some of the latter test pieces being subsequently burned for 2 hours at cone 14 and cone 18 respectively in a laboratory gas-fired furnace, 3 hours being taken to attain the temperature. The drying and firing shrinkages, porosity, true and apparent specific gravities, refractoriness, reversible, thermal expansion, and resistance to solution by a soda lime, glass and a basic slag were determined. The results obtained are collected in tables or shown by means of curves. A summary of the results is as follows :—(1) Addition of sillimanite to clay decreases the drying and firing shrinkages, increases the porosity at the higher temperatures of burning, and when 50 per cent. or more is present increases the refractoriness appreciably. (2) A mixture of 95 per cent. sillimanite with 5 per cent. ball clay has a regular coefficient of expansion from 15 deg. C. to 1,000 deg. C., which is not affected appreciably by differences in the firing temperature up to cone 18. The rapid expansions shown by fireclays from 100 deg. C. to 200 deg. C. and from 500 deg. C. to 600 deg. C. are reduced by the addition of sillimanite. The expansion of a typical fireclay from 600 deg. C. to 1,000 deg. C. is less than that of sillimanite in the same range. (3) Sillimanite bonded with 10 per cent. of ball clay has a marked resistance to chemical attack by soda lime glasses and basic slag. Sillimanite-clay mixtures containing less than 50 per cent. of sillimanite are not appreciably more resistant to such attack than is fireclay alone.

In a short discussion which ensued, the chairman and others commented on the unlooked-for result that in one or two instances the addition of a vitreous material like glass or slag apparently increased the refractoriness.

Mr. A. S. Green, on behalf of Mr. W. Emery, mentioned that a number of saggars made of 70 per cent. silica with 30 per cent. fireclay had been in use for about a year, and many of them were still in good condition. Also a quantity of firebricks containing 85 per cent. silica (the remainder being half fireclay and half bond clay) had proved successful in use.

Mr. W. J. Rees stated that some sillimanite bricks were being tested in Sheffield, and preliminary trials indicate that they are likely to prove satisfactory in resisting sudden changes of temperature, &c. They are expensive in the first instance, but the true criterion is the cost per unit of production. In the roof of a 3-ton furnace the life of 85 per cent. sillimanite bricks extended over 145 heats, and when the bricks were examined after removal it seemed probable that they would have withstood 30 or 40 more heats, whereas the life of silica bricks under like conditions would only be about 60 heats. There is little doubt that sillimanite bricks will find a field for use in the glass industry.

(To be continued.)

Metrological Apparatus for Japan.—Messrs. Adam Hilger, Limited, 75a, Camden Road, N.W. 1, inform us that they have been entrusted with the manufacture of the interferometric apparatus to be used for the establishment of the metre in Japan, in connection with the law passed by the Japanese Diet in March last, making the metric system compulsory in that country. The apparatus will also provide for the measurement of the 5-metre base, which is the foundation of the geodetic survey in Japan.

The Mersey Tunnel.—The proposal to build a tunnel under the Mersey for the use of the heavy traffic to and from Liverpool, which has at present to be dealt with by ferries and so contributes to the congestion of a busy part of the river, has now reached the stage when an early start may be anticipated. It is now three and a-half years since a committee was formed to deal with the matter, representing all the municipalities on the Mersey who are interested in the proposal. Plans were then prepared for a tunnel of 2,400 yards in length and of dimensions suitable to allow four rows of vehicles to pass through in the upper part and two lines of tramways in the lower division. The scheme is estimated to cost about 7,000,000*l.*, towards which it is anticipated that the Ministry of Transport will make a substantial contribution. The work will take five years for completion and will provide employment for many men who are at present idle.

High Speed Submarine Telegraphy.—With the completion of the laying by the Cable Ship Colonia of a cable between New York and the Azores for the Western Union Telegraph Company, a new era in long distance submarine telegraphy begins. The novelty in the construction of this cable is the use of continuous loading. Instead of using loading coils at intervals, as is common in long distance land transmission systems to obtain the necessary inductance to counteract capacity effects, a tape of a highly permeable nickel-iron alloy known as Permalloy is wound continuously along the cable length. A greatly accelerated service is anticipated from this introduction, and cable engineers await with interest news of the actual speed of transmission attained. The laying was only completed last Saturday at Horta, where a Western Union Station has been established. It should be stated that the cable was made and laid by the Telegraph Construction and Maintenance Co., Ltd., of London, and that credit is due to the Western Electric Company for the production of the alloy of which the loading tape is made. For purposes of communication between America and Southern Europe this cable line will be used in association with one of the ordinary type now being layed between Italy and the Azores.

THE LATE MR. H. K. G. BAMBER.

As a result of a motor accident at cross-roads on the rebuilt Watling Street, near Gravesend, Mr. Henry Kelway Gwyer Bamber, who will be long remembered for his work in connection with improvements in the manufacture of cement and its use in constructional work, was killed on Saturday, the 20th inst. Mr. Bamber was born at Pinner on February 5, 1864, and was the son of Mr. H. K. Bamber, a well-known analytical chemist who practised in Westminster. After completing his education at University College, London, and the Royal School of Mines, he entered his father's laboratory. In 1887, by his appointment as chemist to Messrs. J. R. Patrick and Son, of Dovercourt, Mr. Bamber became first associated with the cement industry. Seven years later he entered the service of Messrs. Knight, Bevan and Sturge, of Northfleet, and later became a partner in the firm. When the Associated Portland Cement Manufacturers, Limited, was formed in 1900, by a combination of the leading firms, Mr. Bamber was given a seat on the board, and remained one of the managing directors until 1923. He was also a managing director of the British Portland Cement Manufacturers, Limited. Mr. Bamber, however, did not confine his activities to the improvement of the production of cement, but took a large part in developing its use in concrete construction. He was one of the founders of the Concrete Institute, now the Institution of Structural Engineers, and at the time of his death was Vice-President. He did useful work on the subcommittee of the British Engineering Standard Association, in framing the standard specification for Portland cement, and acted as chairman of the first International Cement Congress, which was held in the spring of this year. Among those who have taken part in the development of industrial welfare work, Mr. Bamber must be reckoned as a pioneer. He early saw its value, and before any definite organisation had taken the matter up he started schemes for the benefit of the workers of the concerns with which he was associated. He was an Associate of the Institute of Civil Engineers, a Fellow of the Chemical Society and of the Society of Chemical Industry.

THE LATE MR. GILBERT ROWE.

A WELL-KNOWN Sheffield engineer, Mr. Gilbert Rowe, of Messrs. Craven's Railway Carriage and Wagon Company, Limited, died at the early age of fifty, at his residence, Dam House, Sheffield, on Saturday, September 20. He received his general education at the College of the City of New York, and his technical training in the Stevens Institute of Technology, New Jersey, U.S.A. After obtaining experience in the workshops of the Sprague Electric Company, Mr. Rowe was promoted installation manager, and erected the goods-handling equipment of the Boston Terminal station. In 1898, he came to England as resident engineer for the company and erected the lift equipment of the Central London Railway. After two years' service with Messrs. Waygood-Otis, Limited, London, Mr. Rowe was appointed an assistant engineer to the Underground Electric Railways of London, and had charge of the design and installation of lift equipment, stairways, ventilation plant, cable transmission systems and fire services. In 1907 he was appointed resident engineer for Europe for the Otis Elevator Company. He erected blast-furnaces and charging machines at Dowlais, Hayange, in Alsace-Lorraine, and at Prague in Bohemia. He designed the interlocking and opening mechanism for Creek Bridge, Greenwich, for the London County Council, and under Mr. David Hay, was engaged in consulting work for Messrs. Norton, Griffiths and Co. He was then engaged on the design of the London South Side Main Sewer electric equipment, and laid out complete works in Paris for the Sturtevant Engineering Company. Mr. Rowe was retained by Mr. W. J. E. Binnie on the electric pumping scheme for the Genoa Waterworks. He was consulting engineer to Messrs. Hayward, Tyler and Company, Limited, the Sturtevant Engineering Company, Limited, and the Leeds Forge Company, Limited. In part of the war period he acted as inspecting engineer in the United States of America for the General Electric Company, Limited, in connection with the production of munitions components. In 1917, he was appointed to the post of chief engineer to Craven's Railway Carriage and Wagon Company, Limited, of Darnall, Sheffield, which post he held until his death. Mr. Rowe was a member of both the Institution of Civil Engineers and the Institution of Mechanical Engineers.

MECHANICAL STOKERS.—The Riley Stoker Company, Limited, Palace Chambers, Bridge-street, London, S.W.1, have recently acquired the sole rights for British production and sale of the Riley, Harrington, Jones and Murphy Stokers, and will in future deal with all matters relating to them from the address given.

LETTERS TO THE EDITOR.

PATENT OFFICE SEARCHES.

TO THE EDITOR OF ENGINEERING.

SIR,—When an application is filed with a complete specification for the grant of Letters Patent for an invention, the Examiner, among the other investigations which he is called on to make, has to search the records of patents granted during the past 50 years and to bring to the notice of the applicant any relevant prior specification. The search by British examiners is limited to British specifications. In some countries, for example, in France, no search is made. In other countries, for example, in Germany and in the United States of America, a very much more extended search is conducted, patents of all principal countries and technical literature being involved.

It has frequently been suggested that the search made by the British Patent Office should be made more extensive, and the Patent Office officials given greater power than they possess at present in refusing to grant patents for matters in which it cannot be proved to their satisfaction that a real invention exists, that is to say, such an advance in the art as entitles one to consider that an act of invention has been made.

It would assist inventors in some cases, but be detrimental to them in others, if such wide powers were held, because at the time specifications are filed inventors are not usually able to bring to the notice of the Comptroller in many cases the proofs which might be required.

On the other hand there is much to be said for the extension of the ground covered by the official researches, seeing that under the latest Patent Act a document which cannot be brought to the notice of the applicant by the examiner may officially be cited by an opponent in opposition proceedings and, if successful, the patent may be refused.

A recent case in which this occurred proves that it is a matter of some importance. The subject-matter in question is immaterial because the case applies generally.

A specification had been allowed by the Comptroller containing eight claims. This allowance took place after the Examiner had made his search and had been satisfied with the applicant's amendments. The grant of the patent was opposed by an interested party on the ground that the invention had been published in four United States specifications. According to the official report at the hearing the Comptroller-General found that five out of the eight claims in the applicant's specification were anticipated, and although in doubt as to whether he could allow the specification to be amended in such a way as to limit the invention to what were subordinate features, he allowed an amended specification to be submitted and then found that it was not acceptable, mainly on the ground that it claimed an invention different from that which had been applied for originally. He therefore refused to grant a patent. An appeal was made to the Solicitor-General and he upheld the decision of the Comptroller.

Had the Patent Office search been extended to cover United States specifications, the applicant would have been able in all probability to amend his specification during the examination proceedings to the satisfaction of the examiner, and obtain the grant of a patent (possibly with a post-dated date), or he would have been able to abandon his case, and thereby not convey the remainder of the information to the public.

In practice, a number of the examiners at the Patent Office draw attention during examination proceedings to matters not covered by the official search, and give the applicant an option to take these into consideration or not, as he desires.

In view especially of the recently reported case referred to above, it apparently would be well if the search now officially made were extended as indicated. This would result in more confidence on the part of the public as to the novelty of a patent when issued, and in more information being obtainable by inventors officially as to the state of any particular art in which they are interested.

Yours faithfully,
"L.R."

"THE DETERMINATION OF STRESSES BY OPTICAL METHODS."

TO THE EDITOR OF ENGINEERING.

SIR,—The discussion on the determination of stress by optical methods at the Toronto Meeting of the British Association (see page 284 *ante*) was remarkable as indicating how few of the speakers were familiar with the fundamental facts of the subject. As my name was freely mentioned and I was unable to be present I shall be glad if you will give me the opportunity of replying to a number of inaccurate statements made and reported in your issue of August 29, page 284. Mr. Preston states that the photo-elastic method shows only the difference of the principal stresses at any point, and has therefore not realised that purely optical observations give the directions of the stresses and their magnitudes, or all the elements required for the complete specification of the stress at a point. There are at least three purely optical methods known, and these are described in a paper by Professor Filon and myself in the B.A. Report of 1914. Last year Professor Filon published at the B.A. Meeting an improvement of one of these methods with a fully worked-out example, and this was accompanied by a paper of my own giving the reasons why I prefer a combination of optical and mechanical measurements. Both these papers appear in your issue of October 19, 1923, pp. 511 and 512. The mechanical measuring instrument which I use is a very accurate one, and in capable hands gives results within 2 per cent. of the truth, which is usually sufficient for all practical purposes. When Mr. Preston succeeds in producing a better instrument he will be in a more favourable position to criticise the one now in use.

Another speaker questioned the justifiability of applying such results to a steel structure, and it may therefore be of interest to state that it is justifiable to do so, and that the conditions to be observed are well known. The latest information on this part of the subject is given in a paper by Professor Filon in the B.A. Report for 1922.

Evidently the American Government believe they can apply photo-elastic results to a metal structure, as they are making elaborate experiments on an airship model. Some speakers stated that they preferred strain measurements of lines drawn on rubber models. There are, however, basic errors of principle which prevent accuracy in the method of Messrs. Wilson and Gore, who measure the strains of finite lines or circles drawn on the surface. Take a finite circle, for example, in an unstrained sheet, although every infinitesimal circle drawn within it becomes elliptical under stress, the finite circle does not become so owing to stress variations within its contour. It may have, for example, an egg-shaped or pear-shaped contour, and therefore the directions of the principal stresses are indeterminate. Again, the magnitudes of the stresses at a point within the contour are based on measurements of changes of length of lines stretching from one point of the boundary to another point, and since in general the stress varies at every point the average value obtained is always less than the maximum value.

For example, in this way of measuring stress it is impossible to find the maximum stress due to a hole, in a plate, as the average measured along any line passing through the point of maximum stress must necessarily be in defect. Mr. Kimball was therefore quite justified in his objections to experiments on rubber models.

Professor Lea states that optical methods would be much more valuable if they could give information as to dynamic forces, and he will be interested to learn that such effects have been observed in rotating gears by Messrs. Kimball and Heymans, and that their results have been recorded during the last two years in the Proceedings of the American Society of Mechanical Engineers, the General Electric Co's. Journal and possibly in other places. The method involves the use of an interrupted electric beam in conjunction with a phase changer, and is of general application. The discussion was brought to a close by a description by Professor Jasper of his dynamic experiments on the maximum stresses round a hole which he finds to be about one-half the value found by myself. It is not, however, necessary here to discuss whether or no I have made a gross error, as a well-known and exact mathematical solution confirms photo-elastic experiments. If, therefore, Professor Jasper is correct, his experiments are crucial, and demolish the whole theory of the elastic strength of materials now current. This seems unlikely. Professor Jasper goes on to state that we are on the eve of a method of determining stresses which will not depend at all on optical principles, but if this method depends on Professor Jasper's dynamic experiments I think there is likely to be some delay in the fulfilment of the prophecy.

Yours faithfully,
E. G. COKER.

On Board SS. Olympic, September 9, 1924.

RUSSIAN NAVAL PROGRAMME.—It is stated by the Russian newspaper *Segodnia* that a four years' naval construction programme has been drafted by the Soviet Government. For the Baltic fleet it is proposed to build two light cruisers of 3,000 tons displacement and with a speed of 23 knots, four destroyers of 1,400 tons displacement to be propelled by steam turbines at a speed of 36 knots, seven submarines and three anti-submarine motor boats. It is also proposed to construct a light cruiser, eight destroyers and 12 motor boats for use in the Black Sea, as well as four gunboats for service in the Pacific and two for use in Arctic regions.

MEASURES TAKEN IN SWEDEN AGAINST ICE TROUBLES AT WATER POWER PLANTS.*

By A. FREY SAMSIOE, Vattenbyggnadsbyran, Stockholm, Sweden.

ICE is a source of trouble to many hydro-electric plants all over the world. The extent to which disturbances may be expected varies with the hydrological conditions in the river on which the power station is situated and with the severity of the winter season. The worst trouble is not caused by the ice in the extreme north, as here the occurrence of ice sludge (Frazil ice.—ED., E.) is less frequent and the other menaces of the ice are so evident that adequate measures are generally taken to meet them. In the middle and southern parts of Sweden, such measures are sometimes considered too expensive and are therefore omitted, with the result that serious troubles occur when occasionally the winter cold gets severe.

Rapids above power plants are always a source of trouble. In these, anchor ice is likely to form on the boulders in the river bottom, and this ice when loosening may produce a formidable jam. Furthermore, in the rapids the water comes into close contact with the air, with the result that, in cold weather, the whole stream gets saturated with ice needles producing a troublesome ice sludge. In Sweden it is necessary to pay very close attention to the necessity of either dredging such rapids or submerging them by raising the water level in front of the dam sufficiently. By creating a still-water basin, extending far up the river, the risk is not altogether obviated, as ice sludge may set in during cold storms occurring before the water is covered with ice. When a cold storm blows upon the unprotected water, the strong wind prevents the formation of an ice sheet, and instead the whole water becomes saturated with ice needles which readily fasten on to any object in the water, thus gradually forming on this a piece of solid ice. In a comparatively short time enormous quatities of such ice needles can be formed. Conditions are still worse during snow storms, as the snow is blown from the adjacent fields into the water.

An ice sheet being the best safeguard against sludge, its formation is often, especially in the northern part of the country, facilitated by artificial means in canals and streams, where the velocity of the water is so high that the surface otherwise would hardly freeze. To this end wooden ribworks or logs, floating upon the surface of the water are arranged in the stream. The surface velocity is decreased, ice needles fasten on the logs and become nuclei for the formation of ice floes, and soon a sheet of ice covers the stream.

On the occurrence of sludge the screens in the turbine intakes are apt to get clogged up, if adequate means are not provided to prevent the ice needles from fastening on them. Even the turbines may sometimes be choked, but this is not so much to be feared in modern big units with their very large openings. As to the screens, the most effective remedy is to remove them entirely, provided, however, that this is advisable with respect to the turbines, and allowed under fishing regulations. As the close screens at the power plants are generally required only as a means of protecting migrating fish, and, during the winter proper, the fish do not migrate, it is consequently permissible to remove the screens or to replace the ordinary screens by screens with larger openings, preferably made of wood, as the ice does not so readily fasten on wood as on to steel. In most places this can be done. The last method is, however, not sufficient at places where particularly serious sludge may occur. At such places very good results have been obtained by electric heating of the steel bars of the screen. At Lower Hemsjö, located in the southern part of the country, sludge troubles are now entirely avoided in this way. In the screens the steel bars are electrically connected in such a way that the heating can be effected by electric current at 125 volts. The required energy is very small, amounting to only 10 kw. for each screen with an area of 15 sq. metres (about 160 sq. ft.) As no insulating material but wood is necessary, the installation is quite cheap, and most of the difficulties due to ice sludge can be avoided at a comparatively small expense.

To prevent the formation of ice in recesses and on the water line, superstructures are erected, often extending over the whole turbine intake, and heated with hot air from the generators.

The formation of ice also tends to hamper the operation of Stoney gates and other movable parts. At the turbine intakes ice is likely to form in the recesses for the sluices above and around the water line. In plants where a superstructure over the whole intake is considered too expensive, it has been found a good plan to cover up the intake with wooden flooring under which hot air is led from the generators. In this way even the formation of ice on the surface and on the intake walls is prevented.

At the sluices in dams ice is formed on the upstream side. Leakage causes the formation of ice in the recesses and on the downstream side of gates. It is not necessary to provide means for the operation of *all* movable parts during the winter, as some of them are intended for flood discharge only and there is no need to move these during winter time. The precautions may thus be concentrated on certain sluices only, suitable for winter discharge.

To prevent ice from forming on the staunching rods, on their metallic guides and on the surrounding masonry, these parts can be electrically heated. This is now generally done by means of special radiators at 110 volts. A supply of about 2 kw. per square metre (0·2 B.T.U. per square foot) is sufficient to prevent ice from fastening, even on the most exposed parts, at a temperature of — 20 deg. C. (— 4 deg. F.).

With a view to preventing the formation of ice in the recesses, a good practice is to blow out heated air from the generators into them by means of fans. In many places where steam is available—for instance, when the dam is located close to a factory using steam—good results have been obtained by utilising this for heating purposes.

Where Stoney gates, in winter, have to be moved only occasionally, and therefore electric heating is considered unnecessary, and if heated air or steam cannot be supplied to the recesses, the removal of the ice is much facilitated if the recesses are made so spacious that a man can easily climb down into them. In recent designs of Stoney sluices the number of rollers has been decreased and the rollers have been made rather big, in order to dispense with small movable parts which are apt to be jammed. Stoney gates, 15·5 m. (51 ft. 1 in.) wide and 5·7 m. (18 ft. 9 in.) high, supported at each end by four rollers only, 40 cm. (16 in.) in diameter, are now being installed at Sikfors, located in the northern part of the country. At these gates the lower roller has been placed so high up that it is never submerged in the stream of water passing through the gate opening.

In order to prevent the formation of ice on the upstream side of the gates, these are often provided on the down-stream side with a wooden boarding, by means of which the whole steel structure is enclosed in a chamber which may be heated when necessary. At Untra, located in the central part of the country, where ice of a thickness of 0·5 m. (20 in.) previously used to form on the upstream side of the gates, no formation of ice has occurred after such boarding was provided, although no heating has been resorted to.

Steel pipe lines and surge tanks in the northern parts of Sweden are generally insulated against the cold by means of roofing or some other kind of superstructures, into which, as an additional precaution, hot air from the generators is often blown.

Another difficulty is due to the pressure of the ice against the dams. This pressure is generally explained as follows: During period of intense cold the surface of the ice gradually assumes the temperature of the air, which results in tensile stresses and cracks. Some of these cracks get filled with water, which soon freezes. Later, when a mild day comes, the temperature of the ice is raised to about 0 deg. C. (32 deg. F.), which results in pressure in the ice. If the ice abuts on a dam, this dam will suffer under the pressure. The magnitude of this pressure has, no doubt, in many cases been much overrated. As a matter of fact, the ice acts very much as a fluid slowly yielding under pressure. As considerable changes in the temperature of the air do not occur instantly, and as, in any case, it takes some time before any great change of the temperature of the ice ensues, especially when the ice is covered with snow, the ice will gradually yield and the resulting maximum pressure will be much less than has been calculated in several extreme cases. In an interesting article N. Royen shows that the pressure from an ice field will not exceed 30 tons per linear metre (9 tons per linear foot) when the ice is 1 m. (40 in.) thick, and 20 tons per linear metre (6 tons per linear foot) when the ice is 0·75 m. (30 in.) thick. Ice fields of such thickness, naturally, do not appear in Sweden except in the northernmost parts of the country. In the south of Sweden the maximum thickness of the ice fields is about 0·5 m. (20 in.). As the ice pressure is nevertheless inconvenient, many means have been invented to decrease or eliminate it. It has thus been proposed to give the dams a sloping upstream face so that the ice should slide up along the incline, or to introduce some plastic material between the facing and the supporting structure, thus allowing a certain amount of yield. Generally the dam owners content themselves with cutting slots in the ice in front of their dams and with covering these slots with spruce branches and snow, or straw and manure, and, as a matter of fact, there have been very few instances in Sweden of ice pressure causing any damage.

* Paper, abridged, contributed to Section B of the World Power Conference on July 4, 1924.

CONVERSION OF RIVER HOSPITAL STEAMERS FOR NILE TOURIST SERVICE.

MUCH ingenuity has been applied to the utilisation of war material for the requirements of peace conditions, and several examples of this class of work have been illustrated and described in our columns on previous occasions. We now propose to give an account of a particularly interesting example of ship reconstruction work included in the same category, and carried out for the purpose of rendering vessels designed by Professor J. H. Biles for use as hospital steamers on the River Tigris, suitable for carrying tourists on the Nile between Cairo and Assuan, a distance of 583 miles.

In order to enable our account of the conversion work to be more easily followed, we reproduce, in Figs. 1 to 6, on page 464 of this issue, a photograph, profile and deck plans of a boat numbered H.P.12, which formed part of the fleet as originally designed for the Tigris hospital service. Two of these vessels, numbered H.P.13 and H.P.15, were in Egypt at the close of the war, having been diverted, while on their way out to the Persian Gulf, for service on the Nile in connection with the Inland Water Transport Department of the British Army. These vessels were purchased from the Disposals Board in 1921 by Messrs. Thomas Cook and Son, Limited, and the work of converting them for the Nile tourist service was carried out in Messrs. Cook's Boulac Engine Works, at Cairo, by Mr. Thomas Reynolds, the firm's superintendent engineer. The Boulac Engine Works, it should be explained, are used for the overhaul and repair of some 22 steamers and 6 sailing dahabeahs, which form Messrs. Cook's fleet on the Nile. Native labour is almost exclusively employed.

As originally constructed, the vessels were 225 ft. 6 in. long between perpendiculars, the beam being 30 ft. and the moulded depth 6 ft. 6 in. They were propelled by feathering side paddles of 12 ft. 6 in. mean diameter, the paddles of each vessel being driven by two sets of compound engines, having cylinders 18 in. and 35 in. in diameter, with a piston stroke of 54 in. The engines were each capable of developing about 500 indicated horse-power at a speed of 50 r.p.m. when supplied with steam at 140 lb. per square inch, so that the total horse-power of each vessel was 1,000. At this power the speed attained was about 12 knots, which was higher than was needed for the tourist service, and, consequently, one set of engines was removed from each boat. The other set, in each case, was placed at the after end of the vessel and arranged to drive paddles at the stern, the vessels thus being converted into stern wheelers. The two original paddle wheels were employed, but the mean diameter was reduced to 10 ft. 7 in. and they were almost completely enclosed in a steel-plate casing, so that, in their present form, the vessels resemble screw-propelled steamers. This can be seen on reference to Fig. 7 on page 465, which is reproduced from a photograph of the H.P.15 in service after conversion, this vessel now bearing the name Damietta. The other steamer, originally bearing the number H.P.13, is now named Rosetta. It will be noticed from Fig. 7, and from the drawings reproduced in Figs. 8 to 14 on the same page, that the boiler has been moved right forward to preserve the trim of the vessel. The boiler, which is of the Yarrow water-tube type and was constructed by Messrs. Babcock and Wilcox, was originally arranged for oil firing, but has now been modified for burning coal by adding the necessary grate and cleaning doors. Steam is generated at 200 lb. per square inch, but the pressure is reduced to 140 lb. per square inch at the engine stop valve by means of a Cockburn-McNicholl reducing valve.

For the work of conversion, each of the vessels was dry-docked at the Boulac works, and after the whole of the machinery had been taken out, the main, upper and sun decks were removed and the hull cut through just abaft the after oil-fuel tank shown in Fig. 6 on page 464. A new stern portion with parallel sides, and designed to accommodate the stern wheels, was constructed and attached to the original main portion of the hull. By this means the length of the boat between perpendiculars was increased to 231 ft. 6 in. No alterations were made to the forward portion of the hull, but the boiler seatings were, of course, removed from their original position amidships and located right forward.

The upper structure, however, was entirely reconstructed to provide luxurious accommodation for 60 passengers, most of whom are carried on the upper deck as shown on the plan, Fig. 12, on page 465. There are now 36 single and 12 double staterooms, many of which, as shown, are provided with a private bathroom. Each cabin is fitted with a four-post bed, wardrobe, fixed porcelain hand-basin with hot and cold filtered water supply, electric heater, fan, &c. On the main deck amidships, as shown in Fig. 13, is situated a dining saloon with 15 tables each seating four persons, and immediately aft of this is the smokeroom. The forward portion of the upper deck has been formed

CONVERSION OF RIVER HOSPITAL STEAMERS FOR NILE TOURIST SERVICE.

MESSRS. THOMAS COOK AND SONS, LIMITED, BOULAC ENGINE WORKS, CAIRO.

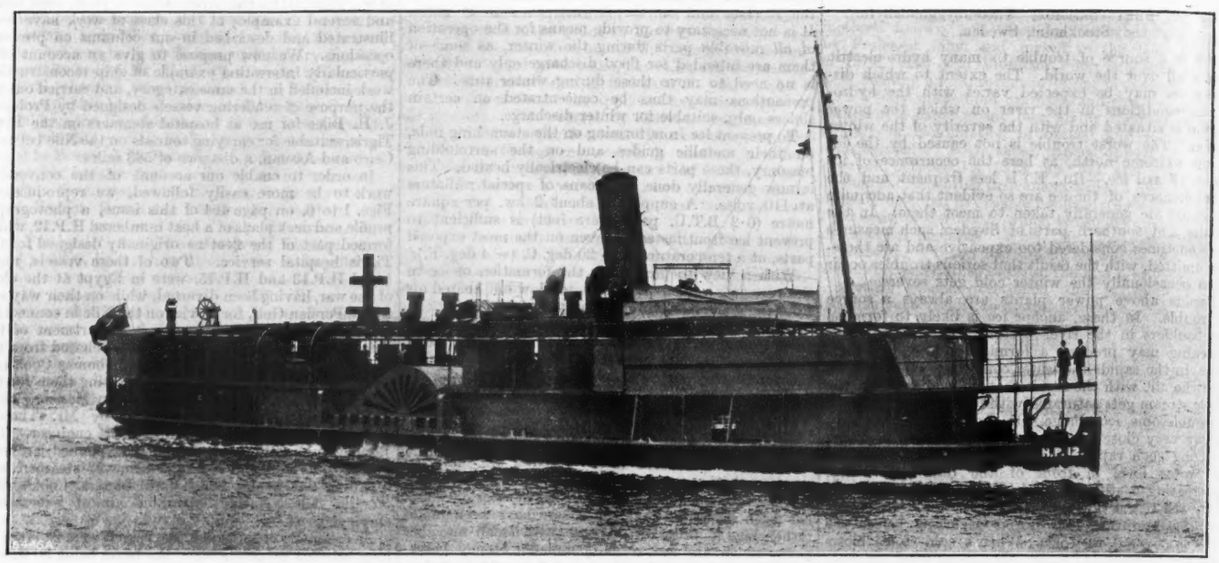
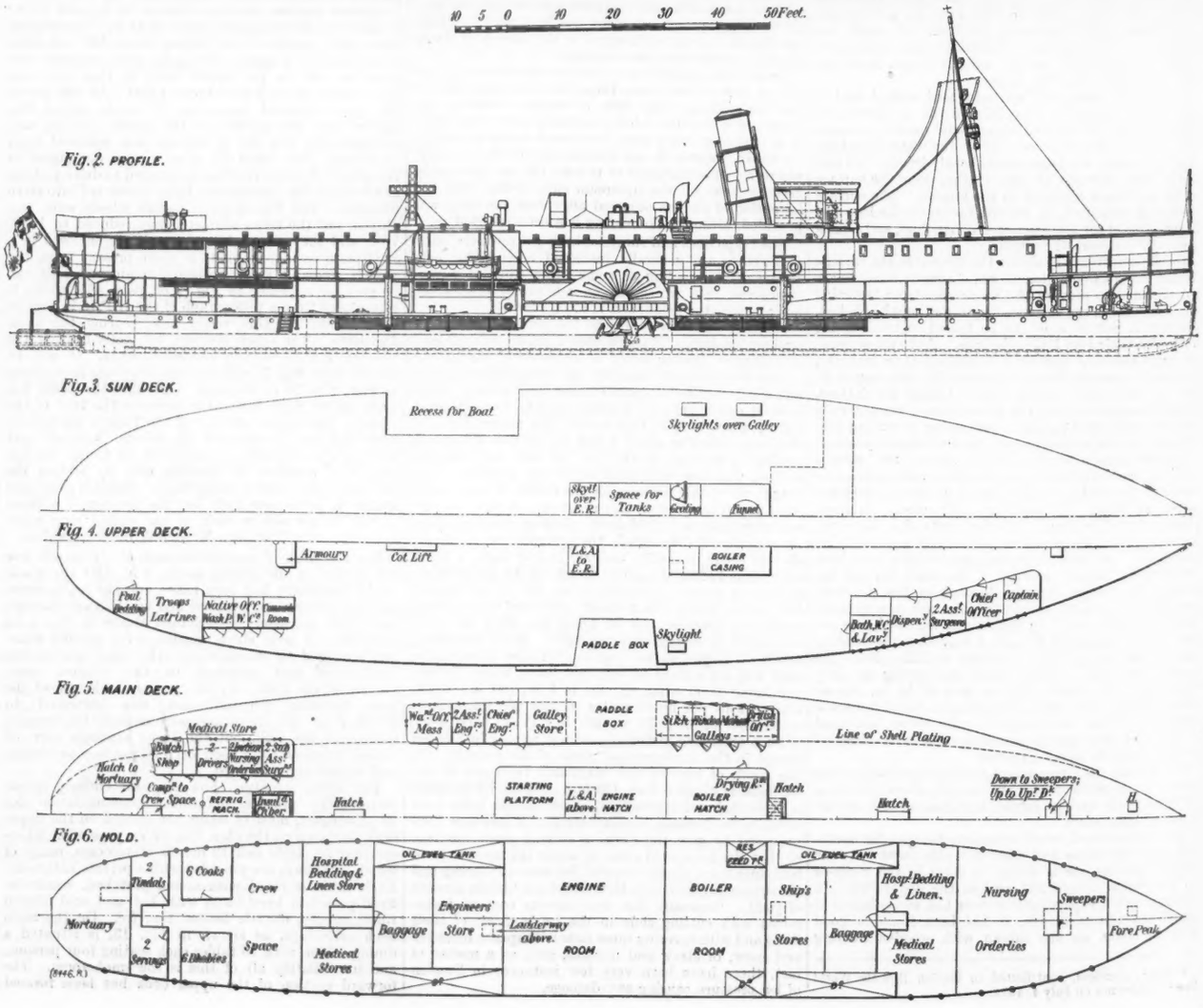


FIG. 1. VIEW OF HOSPITAL STEAMER PROPELLED BY SIDE PADDLES.



FIGS. 2 TO 6. PROFILE AND DECK PLANS OF HOSPITAL STEAMER.

CONVERSION OF RIVER HOSPITAL STEAMERS FOR NILE TOURIST SERVICE.

MESSRS. THOMAS COOK AND SONS, LIMITED, BOULAC ENGINE WORKS, CAIRO.

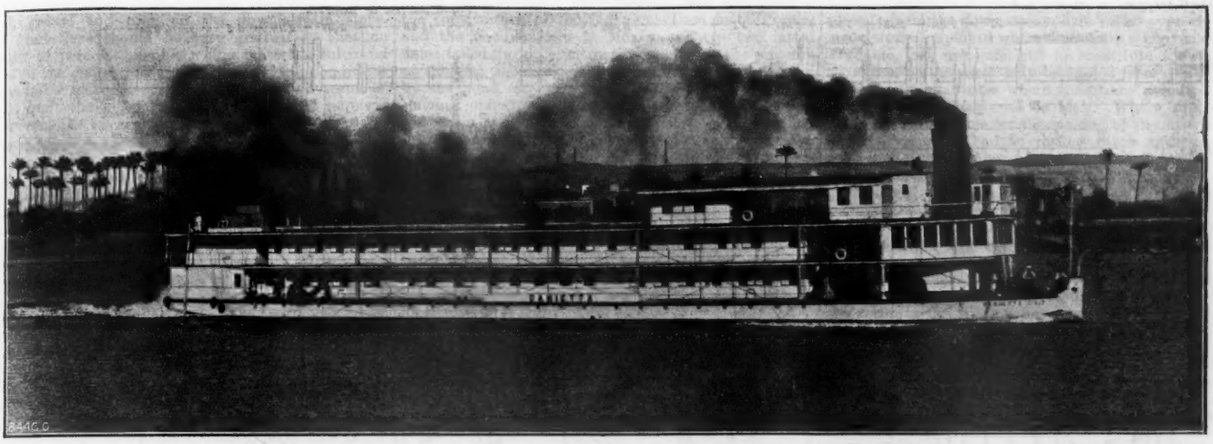
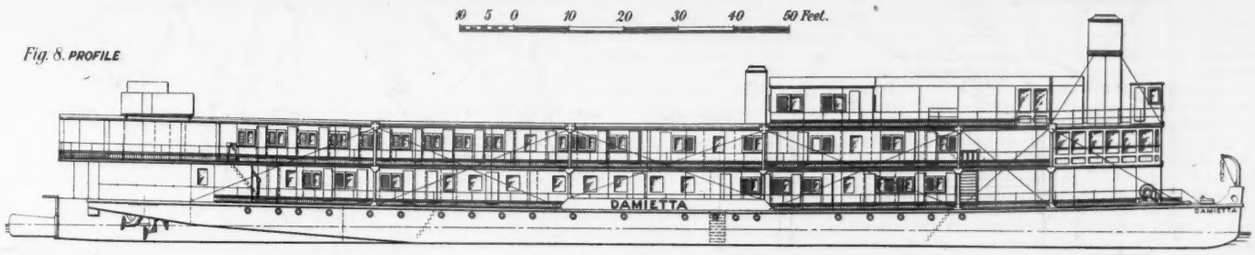
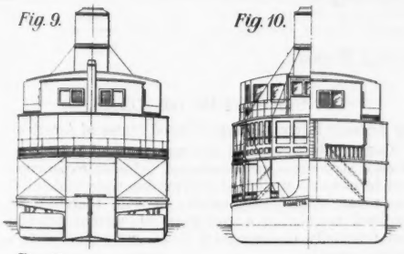
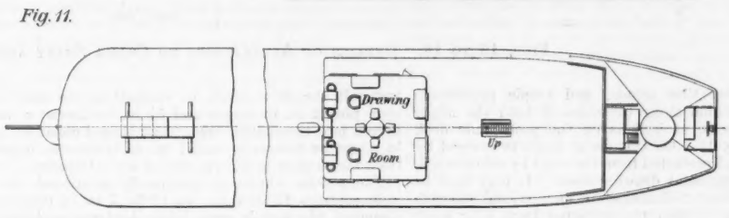
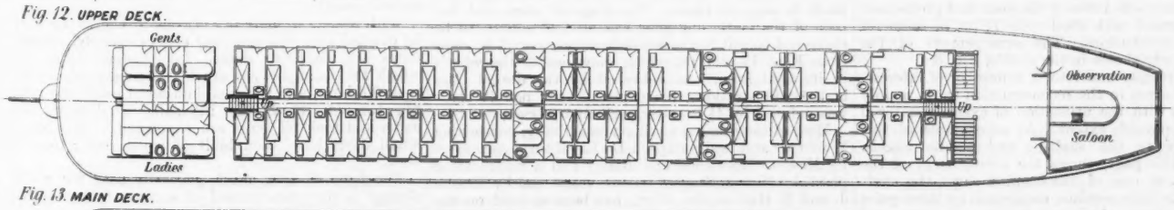


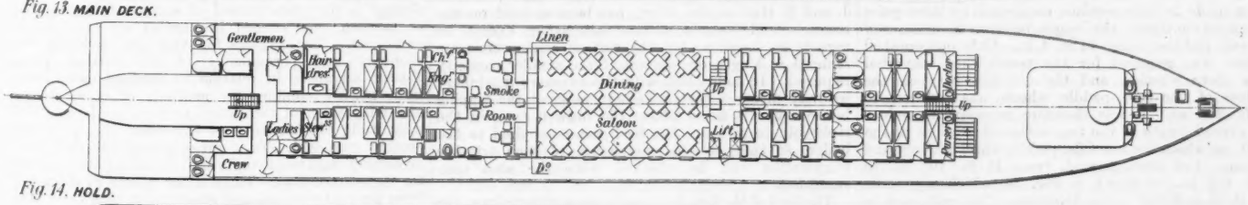
FIG. 7. STERN-WHEEL TOURIST STEAMER "DAMIETTA" IN SERVICE ON THE NILE.

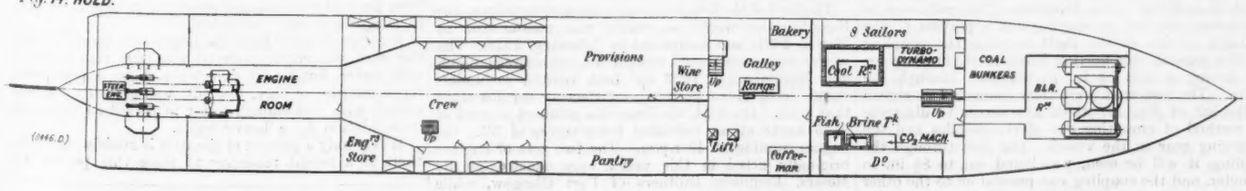








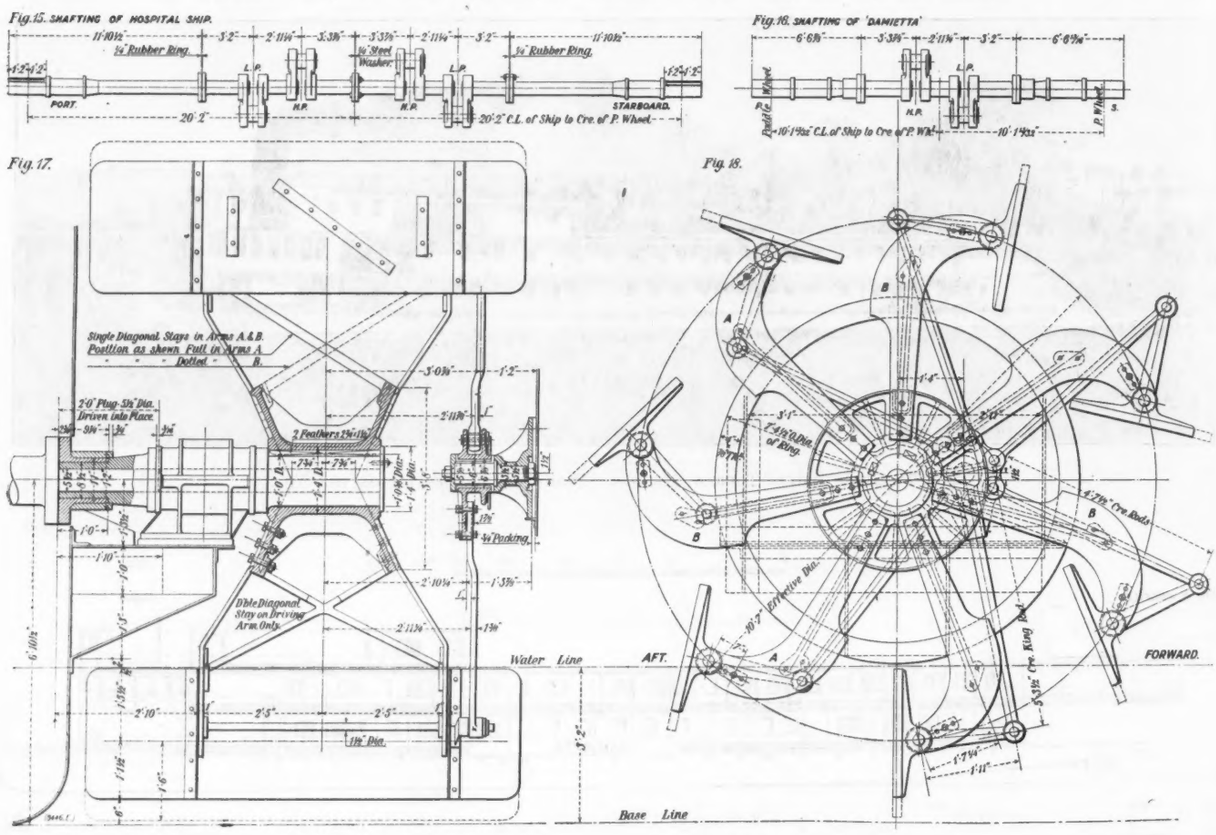




FIGS. 8 TO 14. PROFILE, END ELEVATIONS AND DECK PLANS OF STERN-WHEEL TOURIST STEAMER "DAMIETTA."

CONVERSION OF RIVER HOSPITAL STEAMERS FOR NILE TOURIST SERVICE.

MESSRS. THOMAS COOK AND SONS, LIMITED, BOULAC ENGINE WORKS, CAIRO.



FIGS. 15 TO 18. DETAILS OF ALTERATIONS TO CRANK SHAFT AND PADDLE WHEELS.

into an observation saloon, and ample promenade space is available along the sides of both the upper and main decks, as well as on the promenade deck shown in Fig. 11. On this deck, which is covered by a sun deck and protected from the wind by side screens, is located a pleasant drawing room. It may here be pointed out that, to increase the longitudinal strength of the vessels in their reconstructed form, king posts composed of 6-in. by 3-in. channels were fitted at intervals on each side between the main and promenade decks and braced with steel rods 1¼ in. in diameter fitted with turnbuckles. The arrangement of the bracing is clearly shown in the profile, Fig. 8.

As will be readily understood, a number of interesting problems arose in the reconstruction work, mainly in connection with the utilisation of existing material to the fullest possible extent. As an example of this we may refer to the shafting and paddle wheels. Fig. 15, on this page, shows the arrangement of the paddle shaft of one of the hospital ships, the shaft being made in four sections connected by three pairs of flanged couplings, the length between the centres of the side paddles being 40 ft. 4 in. Only one cranked section was required for the vessel when converted to a stern wheeler, and the distance between the centres of the two paddle wheels was reduced to 20 ft. 2$\frac{15}{16}$ ins. It was therefore necessary to reduce the overall length of the two outboard sections of the shaft, on which the journals, paddle wheel seatings and keyways had been formed, from 11 ft. 10½ in. to 6 ft. 6$\frac{15}{16}$ in., as shown in Fig. 16, which represents the shaft as fitted on the Damietta. The reduction in length was effected by cutting out a portion of the outboard section of the shaft between the coupling and the journal, this portion being 11 in. in diameter and having a hole 5½ in. in diameter through the centre. The two ends were then connected as shown on the left of Fig. 17, which also serves to illustrate the method of mounting one of the paddles and the feathering gear in the vessel. The hole through the coupling, it will be seen, was bored out to 8½ in. in diameter, and the coupling was pressed on to the other portion of the shaft, which was turned down externally to fit the enlarged hole. Two keys were fitted to transmit the drive, and, to strengthen the joint, a steel plug 2 ft. in length and 5½ in. in diameter was driven into the central hole, while a steel collar 11 in. in diameter internally and 1 in. in thickness, forged from the surplus shaft, was shrunk on externally.

The paddle wheels, as previously mentioned, were reduced from 12 ft. 6 in. to 10 ft. 7 in. in effective diameter, the paddle arms being shortened and fitted to the original boss, while new forged-steel rings were made to support them. The diagonal stays and the rods of the feathering gear had also, of course, to be shortened to suit the reduced diameter, as will be clear from Figs. 17 and 18, which show one of the wheels in its final form. As indicated by the dotted lines in these illustrations, the depth of each paddle blade was reduced by 4½ in. after preliminary trials.

Most of the original auxiliary machinery, comprising Weir's air and feed pumps, a De Laval turbo-generator by Messrs. Greenwood and Batley and a refrigerating plant, by Messrs. Seagers on one vessel and by Messrs. J. and E. Hall on the other, has been utilised on the reconstructed vessels without alteration, except as regards its location, but the surface condensers were reduced in length on account of the smaller capacity required. In connection with the auxiliary machinery we may mention that a Leinert meter of the tipping bucket type is fitted above the hotwell tank in the stokehold to measure the feed water supplied to the boiler, so that on the completion of each trip the evaporation can be checked with the coal consumption.

The first of the two boats to be reconstructed was the Rosetta, the work on which was commenced in March, 1921, and completed in February, 1922. The work on the second boat was carried out between March and November, of 1922 and both vessels, we understand, have given perfectly satisfactory service since that time. On trial, the Damietta attained a speed of 8·75 knots at an indicated horse-power of 522, the engine running at 48 r.p.m. The two sets of engines originally fitted in this vessel were constructed by Messrs. Ferguson Brothers of Port Glasgow, while those of the Rosetta were built by Messrs. A. and J. Inglis, of Glasgow.

CONSTRUCTION OF DAMS,*

By ARTHUR POWELL DAVIS (United States of America).

THE rapid increase in the number and magnitude of dam structures has developed valuable experience, and furnishes a wealth of information upon which this paper can only briefly touch; it will, therefore, be confined mainly to a summary of current practice and especially its departure from, or development of, former practice.

With respect to materials of construction, dams may be divided into two principal classes, namely, earthen dams and masonry dams. Intermediate types, of which the examples are much less numerous, are the rock fill dams, and the combination of earth and rock fill, through which, by insensible gradations, the earth and rock fill types are connected. Also many small dams have been built of wood, and a few of steel.

The type of dam most generally used for water storage is that constructed of earth. Storage dams of earthen type exceed in number all other types combined. The reasons for this are obviously the economy and permanency of the earthen dam. Recent advances in relation to earthen dams have been mainly confined to methods of construction, and adaptation of the design to such methods. The magnitude of structures of this class has, however, greatly increased. To a great extent the design of an earthen dam must conform to the materials available for its construction. These differ widely in character from pure clay to sand and gravel, with wide variations in mixtures of such materials.

It seems to have been the impression formerly that the most watertight material was pure clay puddled with water, but recent experience shows a preference for a mixture of clay, fine silt, well-graded sand and gravel, with just enough water to permit its thorough consolidation by a heavy roller.

Where only a portion of the dam is made watertight, there is a recent tendency to place this portion as

* Paper, abridged, contributed to Section B of the World Power Conference on July 4, 1924.

near to the water slope of the dam as may be, leaving the rest of the dam as a support. It may be said that the ideal design of an earthen dam, where conditions permit, is a heavy blanket of such a mixture on the water slope, backed by coarser materials, grading very gradually from the fine silt and sand to the coarser sand, gravel and rock on the down-stream slope. The gradations should be very gradual so that no danger of percolation of the fine materials into and through the coarse will exist. Where ideal conditions of available material exist the tendency now seems to be to omit the masonry core unless this is required to prevent the ravages of burrowing animals.

As earthen dams far outnumber all others, it is to be expected the number of failures on such structures would exceed others, and this is true; but it is due not alone to their number, but in particular to the vulnerability of such dams, where sufficient attention has not been made to care for flood-water, and to prevent over-topping, or to prevent piping under the foundation, or along conduits, or other possible paths for percolating water. Where the dam is mostly of clay, it is necessary also to guard against sloughing. Modern experiences point strongly to the necessity of providing ample safeguards against these three menaces, and where this is done the earthen dam usually proves the most permanent form possible. In fact, it may normally be regarded as having a tendency to improve and consolidate with age.

Piping is guarded against by a construction of outlet conduits or other structures which may serve as a path for water with unyielding foundations and large and numerous cut-off collars. Where an earthen dam is founded on or near rock, it may be necessary to provide a low core wall extending some distance upward into the embankment, and if the foundation is rock of a broken and seamy character, grouting is sometimes resorted to.

Some of the more striking difficulties with earthen dams have been due to sloughing. This usually occurs when the material handled is largely of clay, which assumes a semi-liquid character when saturated with water. It is therefore an especial menace when handled by the hydraulic process. For this and other reasons it is extremely desirable to have a large admixture of sand and gravel, with the clay where economy will permit. The use of a large proportion of open material, such as sand, gravel, and rock, in the down-stream body of the dam to drain the clay blanket, is frequently relied upon to prevent sloughing. Where the coarse material is not available, drainage pipes have been used in the lower portion of the dam. In the case of the Belle Fourche Dam, which was built entirely of clay, chief reliance was placed upon extreme care in construction through limiting the use of water and in using a heavy traction engine for rolling, which produced satisfactory results.

It has been found by experience that careful and proper mixture of various quantities of earth can be made to give more satisfactory results than those usually found in nature, in regard both to percolation and stability. It has thus been demonstrated that it is practicable to construct dams of satisfactory tightness with sand, gravel, and other materials containing a very small proportion of clay.

Modern practice has virtually standardised, under ordinary conditions, the slopes of earthen dams of 3 to 1 on the water face, and 2 to 1 on the dry face, although steeper slopes have been successfully used under special conditions, especially where the down-stream portion is material coarse enough to eliminate the danger of sloughing. On the Belle Fourche Dam, composed entirely of clay, a slope was provided on the water face of 5 to 1 for a short distance at the base, then 2 to 1 to the normal water level at a full reservoir, and 1½ to 1 above the water-line. These steep slopes were adopted for reasons of economy to reduce yardage, and especially to reduce the amount of concrete paving required on the water slope. This design has been entirely successful so far as slope is concerned. The pavement was breached by waves, but this difficulty has been successfully overcome without danger to the body of the dam.

The theory that an earthen dam must be well drained to prevent sloughing was given a rather unique solution at Sherbourne Lake, in Montana, where the material readily available for construction was mainly clay. In this case a core was provided not of masonry or puddled clay, but of screened gravel, with outlets of drain tile under the down-stream half of the dam, to furnish complete drainage to the up-stream half, and prevent saturation of the lower half. This novel device seems to work perfectly.

Earthen portions of dams are usually spread in layers of 4 in. to 8 in., compacted by sprinkling and the use of heavy rollers or preferably traction engines, which concentrate the load and avoid continuous horizontal joints.

The most important recent development in methods of dam construction has been the adoption in many cases of the hydraulic method of conveyance and deposition, which has been used on works of the greatest magnitude of this character ever built, such as the Gatun Dam at Panama, and the Rimrock Dam in Washington, now under construction. This method was also used in the construction of the Calaveras Dam in California, and the Necaxe Dam in Mexico. These two latter dams failed during construction, owing to the pressure of the clay interior maintained in a liquid condition by the pond on top, replenished with water by the sluicing operations. In both cases the liquid clay forced its way out on the water slope and sloughed into the reservoir. These spectacular accidents have fixed attention upon the liquid properties of super-saturated clay, and the impossibility of its consolidation where water is continuously supplied at the top.

Aside from the economy which may or may not be attached to the hydraulic process, the results of its successful use are due to the skilful employment of the sorting power of water in separating heterogeneous masses of material into their constituent parts, and placing each in its proper position, and has produced ideal results in many cases.

The largest earthen dam yet built in volume of material, though not in height, is the Gatun Dam on the Isthmus of Panama. It has slopes averaging 7 to 1 on the up-stream face, and 12 to 1 on the down-stream, the principal reason for these conservative slopes being to force a long line of travel for percolating water under the dam where the material was considered more pervious than the hydraulic fill placed upon it. Experience at Gatun, together with the accidents at Necaxe and Calaveras, has emphasised the instability of undrained clay which may contain more than 50 per cent. of water, and the limitations upon this method of dam construction. The hydraulic process requires considerable skill and experience for the best results, but when successfully and skilfully employed, probably produces the most compact and watertight bank possible by any process.

A combination of methods now much employed is to place the materials of construction, by means of cars or dump wagons, as dykes along the upper and lower slopes of the dam, and then attack the interior slopes of these dykes with a hydraulic monitor, which washes out the fine material and carries it to the centre maintained at a lower level. The large rocks are left by the water in the dyke, the clay is washed to the centre, and the sand and gravel are deposited between these limits in graded sizes, the finest in the middle of the dam, and the coarsest near the dyke. Such methods require careful manipulation to prevent stratification and consequent zones of percolation into the centre of the dam.

The hydraulic method is particularly valuable in cases where the quantity of clay and fine silt available for construction is very small. The water, with its sorting power, can be made to carry these to the centre where these small quantities are placed and used to the best advantage. Here the use of other methods might necessitate the construction of a core wall. The protection of the water slope of earthen dams from the destructive action of waves is always important and often expensive, especially where rock is not at hand and cement is expensive, as at many remote localities in the West. The usual protection is a pavement of hand-laid rock, placed on a bed of gravel or broken rock. Where such rock is not available, a concrete deck is generally used, but it is noted that on the smooth facing that this affords, the waves run up the slope much higher than on a rougher slope, thus requiring greater freeboard or a parapet wall. For this reason the water slope of the dam is sometimes made steeper above than below the waterline. The gravel or earthen backing behind a concrete pavement is, of course, saturated with water at and below the level of the water in the reservoir, and where high winds carry waves high up the slope, the recession of those waves leaves an unsupported hydrostatic pressure back of the pavement. Cases are known where such pressure breached the pavement, showing the back pressure to be greater than the weight of the concrete slab removed. This danger is easily obviated by making the concrete slabs of such dimensions, up and down the slope, as to possess a weight greater than any pressure that can occur behind them.

In the case of two large embankments of the Deer Flat Reservoir in Idaho, there being no rock available, and cement being costly because of transportation, an interesting experiment was tried. After finishing the embankments to the standard slopes, the tops were widened to a total of 60 to 70 ft. by dumping the coarsest gravel available, which was allowed to take its own angle of repose and receive the action of the waves. These produced beaching and worked the gravel down the slope gradually, the fine silt and sand settling near the base on rather flat slopes, leaving the coarsest material on the slopes above. These banks have been in annual service about fifteen years, and the extra top width has nowhere been reduced one-half, and in some places scarcely at all. There is no prospect of extensive repairs being required for a long time to come.

The use of coarse materials for drainage purposes in the down-stream half of the earthen dam has evolved the combination of earth and rock, where an impervious bank of earth is backed by rock loosely dumped in place to form the down-stream half. This type of dam is sometimes employed where some earth is conveniently available, but not sufficient to constitute the entire structure, or the earth may be hauled from a distance in sufficient quantities where conditions permit, even though the yardage cost be high. Where sufficient earth is not available for the making of an impervious blanket, resort is had to various other materials of construction, as lumber, masonry, or steel.

The combination of earth and rock fill requires the gradation of materials from the earth to the rock to be very gradual, so as to obviate the danger of any of the earth being washed down stream into the interstices of the rock.

In early days several rock fill dams were built in the West employing a deck of lumber on the water slope for excluding the water. These usually gave satisfaction, and recently the practice has been revived in a design for a dam of this type now under construction in Kentucky, which will be higher than any purely rock fill yet constructed, being about 270 ft. high. The security of the rock fill against sloughing gives it an important advantage over the earthen dam for dams of this great height. In this case the water slope is made 1·2 to 1, gradually and slowly becoming steeper toward the top, where it is 1 to 1. The down-stream slope averages 1·3 to 1. For watertightness the up-stream slope is covered by a concrete deck laid on hand-laid stone, under the form of lumber to be left in place.

In other cases a concrete wall has been employed on the water slope, backed by a hand-laid wall of dry stone, and this in turn backed by a heavy fill of rock dumped at random. In such cases it is customary to make the water slope steep in order to economise on concrete. In a dam of this type built near San Diego, known as the Moreno Dam, 150 ft. high, the water slope is 9 horizontal to 10 vertical for the lower 120 ft., and 1 horizontal to 2 vertical above this. The hand-packed wall is 50 ft. thick at the bottom and its up-stream face laid in mortar as rubble masonry. This dam developed bad leakage through cracks in the rubble masonry, which have been stopped by concrete facing. A rock fill dam 160 ft. high on the Stanislaus River, in California, has the concrete facing reinforced. This facing has a thickness of from 36 in. at base to 9 in. at top, and is backed by a hand-laid wall of rock, in which a thickness of 2 ft. next the concrete is laid in mortar. The water slope of the finished dam averages 1·1 to 1. Near Victoria, Colorado, is an example of a rock fill dam 120 ft. high, which is faced with a deck of steel plates; the slope of this deck is 30 deg. to the vertical, and the plates are riveted together through flanges along the edges, with a filler between, thus forming an expansion joint at each line of rivets.

The rock-fill type of dam has not been given due consideration until recently, but the recent successful application of this type of construction to several problems requiring very high dams, indicates its use in future to a greater extent than in the past. There are many cases where masonry dams have been constructed, or rejected after due consideration as too expensive, where a rock fill would solve the problem as well and more cheaply.

Masonry Dams.

The earliest masonry dams, and a large proportion of the most modern ones, depend for stability upon their weight alone.

All these heavy structures and many later ones seem to have been designed on assumptions of complete uplift water pressures on the entire base of the dam, or on horizontal joints, and some engineers argue that this is the true and only safe theory to employ. This assumes that there is no point of contact between the upper and lower masses forming the joint between which the pressure is supposed to occur. Also that the water may freely enter this joint, but cannot escape on the lower side of the dam. These conditions are impossible of attainment, and could not be approximated except by special effort to do so. It is now the practice to take special precautions to prevent such uplift, by grouting the foundations, by efforts to secure the watertightness of the masonry on its water face, and by providing drainage galleries to collect and dispose of any leakage that may occur in the dam or its foundation. Notwithstanding these precautions it is customary to assume some uplift, and the addition of weight to overcome this.

The most effective means of safety against this and many other dangers, where practicable, is to give the gravity structure a curvature in plan, so that it cannot fail either by overturning or sliding without introducing arch action, and thus transmitting the pressure to

DRAW-OUT TRUCK-TYPE HIGH-TENSION SWITCHGEAR; EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. FERGUSON, PAILIN, LIMITED, ENGINEERS, MANCHESTER.

FIG. 1.

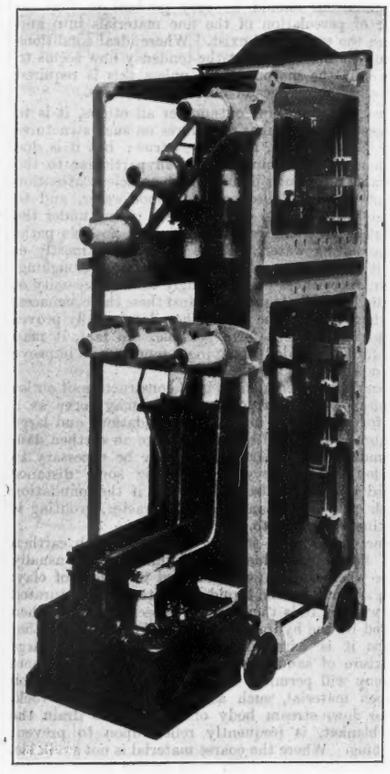


FIG. 2.

abutments. Under such conditions it cannot fail without crushing the masonry or its abutments, and this additional stability is secured without sacrificing any of its virtues due to gravity alone.

Perhaps the most notable failures of masonry dams in recent years were the Austin Dam of Texas, and another near Austin, Pennsylvania. In both cases the foundation was upon stratified rock, with bedding planes nearly horizontal, and the failure in both cases was due to sliding on one of these natural planes below the base of the dam. The introduction of water under pressure head of the full reservoir into these horizontal joints caused sufficient uplift to overcome the sliding friction, which was probably small, owing to the presence of lubricating material like clay or talc. In the case of the Pennsylvania dam the gorge was narrow, and security in abundance could have been obtained by curving the dam, without much additional expense. The Texas dam was much longer, so that an effective degree of curvature would have been more expensive.

Sometimes the curved form is made to economise masonry, permitting a lighter cross section than otherwise, but still retaining the theoretical gravity section, but with a smaller factor of safety in this particular.

Masonry dams arched in plan, may be divided into three classes: (1) Those depending on gravity for stability, but curved in plan to obtain greater security against uplift or other contingencies. Examples of this kind are numerous, as the Cheesman Dam in Colorado, the Roosevelt in Arizona, the Arrowrock in Idaho, and the Don Pedro in California. (2) Those too light to depend on gravity alone, but heavier than if dependence were placed on the arch alone. Examples of this type are the Sweetwater, in California, the Shoshone and Pathfinder in Wyoming. (3) Those depending almost wholly upon the arch form for stability. The Zola Dam, in France, and the Bear Valley, in California, were pioneers of this type, to be followed later by many others in Australia and the United States, of still bolder section, where dependence is placed upon the arch entirely. Of these, one of the boldest is one constructed in Oregon, which is one of the lightest, and is said to vary considerably from a true circle, due to defective construction, and to have had a heavy flow of water over its crest, for which it was not designed, yet it stands intact.

The effectiveness of the arch in the design of dams is inversely as the length of the radius, and in very wide canyons this radius must be so long as to make dependence upon arch action impracticable. The limit of effectiveness is usually taken as about 600 ft., though longer radii than this are sometimes employed to increase the safety of gravity designs. Practically all dam sites are wider at the top than at the base, and this suggests the variation of the radius, so as to employ at all elevations the shortest practicable radius. This device has been patented, and has been successfully employed on a number of high dams recently constructed. Where adapted to conditions it affords economy of yardage, and places the masonry where it is most effective.

Although light arch dams are numerous and have been much criticised, there is, as yet, no record of failure of such a dam. Many of them are striking demonstrations of the remarkable stability of the arch, and justify the expectation that the arch is to play an important part in the future of dam design.

An early form of diversion dam consisted of an inclined face of lumber, supported at frequent intervals by frame buttresses. A development of this in concrete has been applied to storage dams of considerable height and some have been built of steel. By using concrete arches instead of the deck, we have the multiple arch dam, which is one of the most important recent evolutions in dam design. Many have been built and are in successful operation in this country, one in California, recently completed, being 170 ft. high. In Italy, this type is represented by several recently constructed, of considerable height, one of which recently failed, with great damage and loss of human life. The failure seems to have been due entirely to faulty construction, and should not reflect on the multiple arch type.

The Italian Government has given especial attention to multiple arch dams, and has produced several, of which one, the Tirso, is 240 ft. in maximum height, and is the highest of this type yet built.

A theoretical objection sometimes raised to the multiple arch dam in cold climates is the action of frost on the surface of thin walls, which might be considerable, where one side is exposed to the cold air and the other confines water under high pressure. Considering the rapid development of the art in recent years, and the brief experience with some of the latest devices, we are justified in regarding the science of dam design as still in the development stage.

TRUCK-TYPE HIGH-TENSION SWITCHGEAR.

WE have already described various examples of truck-type high-tension switchgear which are to be seen at the British Empire Exhibition, and now in the two figures above illustrate a further model. Constructed by Messrs. Ferguson, Pailin, Limited, of Manchester, this gear is built on the sectional principle, which permits of the grouping of a number of units together to form a switchboard, as well as their individual use. Any desired service, such as controlling dead-end feeders, use on a ring main, and on duplicate feeder systems, can be performed by this apparatus, synchronising gear being fitted when the control of generating plant is intended. The particular model illustrated is suitable for pressures up to 1,500 volts and currents not exceeding 800 amperes.

The truck is shown in Fig. 1, being removed from the cell by means of hand-operated rack and pinion traverse. The framework consists of two substantial castings, bolted together by means of four tubular spacers, on which the oil-immersed circuit breaker is mounted direct. The front panel is constructed of heavy plate and has mounted upon it the ammeter, of the gravity-controlled type, the traverse handle and the switch-control lever. Small, sturdy springs prevent jar when the circuit breaker opens. The truck also carries the current transformers, which are wound round porcelain tubes, and isolating receptacles. When a potential transformer is necessary it is mounted at the back of the truck, as shown in Fig. 2. The fixed housing contains two bus-bars, cable box and the isolating plugs, and the necessary protective screens are fitted to shield live parts when the truck is removed. A very convenient arrangement of pulleys and flexible wires provide an oil tank lifting and lowering system, facilitating easy working. Finally, a simple series of interlocks prevents either the withdrawal or the replacement of the truck while the circuit breaker is in the "on" position.

THE STEAM TURBINE.*

By the Hon. Sir CHARLES A. PARSONS, K.C.B., F.R.S.

THE object of the present paper is to correlate certain well-known principles of thermodynamics with the practical progress of the steam turbine and with important advances that are being made at the present time. These advances promise considerable improvements in the efficiency of fuel utilisation for the production of motive power.

The story of the steam engine, and later of the steam turbine, is largely the story of progress along the path pointed out by the genius of the earlier pioneers—Savory, Newcomen, Smeaton, the famous Watt, Woolf, Trevethick and others who, in the words of Carnot, were the veritable creators of the steam engine. Theoretical knowledge and mechanical progress have advanced along that path side by side, and to-day the engineer has at his command a comprehensive knowledge of the properties of steam, and indeed of thermodynamics, and almost unlimited mechanical resources for the execution of his designs.

Present-day knowledge of both the theory and the technique of steam engines has justified Watt in the principles which he laid down, which were that the greater the steam pressure and range of expansion, the greater will be the work obtained from a given weight of steam, and that the cylinder should be kept as hot as the steam which enters it. The main development of the steam engine since his time has consisted in an extension of the range of expansion and in an ever-increasing degree of compounding. The separation of the condenser from the cylinder by Watt was followed by the division of the expansion into stages in separate cylinders, finally into four stages in the highest development of the reciprocating engine. The steam turbine carries this subdivision still further, the number of stages included in a reaction turbine of high efficiency being commonly 60 or more. In the compound reciprocating engine, the primary object of compounding is to reduce the temperature range of each individual cylinder, and so to diminish the condensation and loss which occurs when hot steam is admitted into a cylinder the walls of which have been cooled to the temperature of the steam just discharged from it. In a steam turbine, on the other hand, it is interesting to note that the turbine ideally fulfils Watt's principle of keeping the cylinder as hot as the steam that enters it, because the turbine, at any part, is only exposed to the steady temperature of the steam that is passing through it. The extensive compounding which is now adopted in all types of steam turbines designed for high efficiency is of vital importance to their performance.

There appears to be considerable evidence from the results obtained from actual turbines that the efficiency of conversion of the available energy of the steam into kinetic energy is greater at low steam velocities than at high steam velocities. Since the high velocity ratio necessary for efficiency can be attained in two ways, either by reducing the steam velocity or by increasing the blade velocity, the most efficient type would appear to be that in which both steam velocity and blade velocity are kept moderate, by adopting a large number of pressure stages.

The consideration of the complete turbine as a series of simple turbines, in each of which the pressure drop is small, is consistent with a simple mathematical treatment for the determination of the energy available from an expanding gas. By the fundamental principles of hydraulics, if p be the pressure and ρ the density of an incompressible fluid, and if we consider V as the velocity generated at each stage by the conversion of pressure energy into velocity energy, we have simply $\frac{V^2}{2g} = -\frac{\Delta p}{\rho}$, which is true also of an expansible fluid when the pressure drop is so small that ρ is sensibly constant. Thus the total kinetic energy so generated per pound of steam in a large number of stages is $-\Sigma\left(\frac{\Delta p}{\rho}\right)$, or, if v is the specific volume, $-\Sigma(v\,\Delta p)$. We thus see that the available energy of an expanding gas is $-vdp$, for a small pressure drop, and $-\int v\,d\,p$, between wider limits of pressure, without any reference to thermodynamics. But by the principles of thermodynamics this can be identified with the energy equivalent of the drop of total heat.

The principle of compounding finds a simple mathematical expression if we consider the case of a turbine consisting of a large number of simple turbines with a constant velocity ratio. For just as $\Sigma\frac{V^2}{2g}$ for such a series is equal to $-\int v\,d\,p$, so $\Sigma\frac{u^2}{2g}$, where u is the blade speed, must be proportional to this value of the available energy. Thus the value of Σu^2 or of $\Sigma d^2 R^2$, where d is the mean diameter of the blade annulus, and R the revolutions per minute, is a suitable measure of the degree of compounding, and has been adopted as such from the time of the earliest compound turbine, and in turbine design is denoted by the letter K.

The high efficiency of which the steam turbine is capable, the large pressure and temperature range which it can utilise without mechanical difficulty, and the fact that it can be built for very large-power output from one unit, have made it the most suitable prime mover for electric generating stations.

Even with extensive compounding for the sake of efficiency, the turbine is essentially a high-speed engine, and the alternating-current dynamo to which it is coupled has consequently required great modification to convert it into a high-speed type capable of acting efficiently as the consort of the turbine. Fortunately, the relation between the output and speed of an alternator follows nearly the same law (the inverse square) as the steam turbine, and it has always been found possible to keep pace with the development of the turbine prime mover in providing a suitable alternator for it to drive. The combination of turbine and alternator thus rapidly progressed in size to meet the demand for large units, and in all large-power stations using fuel, steam turbines now provide the motive power in sizes ranging up to 60,000 kw. Some of these stations now have a total capacity of supply of 500,000 kw., feeding into wide-spread distribution systems and covering large areas.

In marine work there has been a similarly-rapid progress both in economy and capacity, the marine turbine having advanced in output during 20 years' development from the 2,000 s.h.p. of the Turbinia to the 150,000 h.p. of H.M.S. Hood.

The first marine turbines were directly coupled to the propeller shafting. Under these conditions, on account of the low revolutions, the efficiency was determined by the maximum value of K or $\Sigma d^2 R^2$ that could be provided on a given weight, and in a given space. The value of K necessary for maximum efficiency would have led to sizes of turbine and weights that would have been prohibitive. The association of the turbine with a low-speed propeller put the marine turbine at a disadvantage so long as it remained directly coupled, and its early development was therefore confined to the propulsion of high-speed vessels, such as warships, liners and channel steamers, in which it soon established its superiority over the reciprocating engine. In recent years all marine turbines are connected to their propeller through gearing, and this limitation has consequently been removed. The turbine has now been applied for the propulsion of all classes of sea-going vessels and considerable improvement in economy has been effected by the increased efficiencies of both turbines and propeller when these are allowed each to rotate at its most efficient speed.

High-speed turbines can utilise higher expansion ratios and have a higher efficiency of conversion, and the general result is that steam consumptions have been reduced by the introduction of gearing to less than one-half of that of the early direct-coupled turbines.

Whilst mechanical gearing was introduced in the first place with the object of making the turbine applicable to low-speed vessels, it was soon found to be of value even in higher-speed vessels, and the direct-coupled turbine may now be said to be completely superseded by the geared turbine in all classes.

Mechanical gearing has also assisted in the extension of the field of application of turbines on land. Continuous-current generators, which have been made in sizes up to 3,000 kw. at moderate speeds can now be driven by efficient high-speed turbines, as also can low-frequency alternators and alternators of small or moderate output. The geared turbine has also been used to a considerable extent for the driving of mills, such as textile, paper and jute mills.

It is estimated that the total output of steam turbines on land and sea has now reached a total of over 120,000,000 h.p.

In considering the steam turbine alone, the efficiency is expressed as the proportion of the available energy of the steam which is converted into useful work, and in large turbines this proportion is now in the neighbourhood of 85 per cent. The ultimate measure of the efficiency of the heat engine, of which the heating apparatus as well as the turbine must be considered a part, is the ratio of the useful output to the heat supplied by the fuel. It is necessary, therefore, to include in the assessment the efficiency of heat transmission to the boiler, and the proportion of the heat transmitted to the steam that becomes available for conversion into work, as well as the efficiency of this conversion in the turbine. The development of the turbine has, therefore, brought us to the point where it becomes essential to examine closely all practical means of increasing the efficiency of the thermodynamic steam cycle which alone determines the proportion of the heat supplied to the steam that is available for conversion.

It is known from the laws of thermodynamics that the thermal efficiency of a heat engine depends upon its temperature range; in other words, that, in accordance with Carnot's thesis, the temperature at which heat is supplied and withdrawn should be as widely separated as possible.

There are two cycles of operation well known in the thermodynamic theory of the heat engine. The first is the ideal reversible cycle of Carnot, consisting of two isothermals traversed by two adiabatics. The heat received and heat rejected are, respectively, proportional to the absolute temperatures and the efficiency of such a cycle is therefore $= \frac{T_1 - T_2}{T_1}$. A serious drawback to this cycle is the large proportion of negative work, involved by the adiabatic compression.

The other cycle is that which is most closely followed in all practical steam engines, and is known as the Rankine steam cycle. The heat is received at constant pressure, and during the process of evaporation this is isothermal; but when superheat is added subsequent to evaporation the temperature rises. The heat rejected is also rejected at constant pressure and, in general, at constant temperature, viz., the temperature of condensation. The expansion from the high temperature to the lower is adiabatic, and is effected in an engine separate from both boiler and condenser. The cycle is completed by the return of the condensed fluid to the boiler by the feed pump.

It will be readily seen that, for saturated steam, the Rankine cycle has this advantage over the Carnot cycle, that the negative work is reduced to the almost negligible amount necessary to return the feed water to the boiler. The practical superiority of the Rankine steam cycle and the ability of the steam turbine to work on this cycle is the explanation of the success of steam as a working fluid, in spite of the comparatively low temperature at which heat is received. The sole defect of the Rankine cycle for saturated steam is the necessity to re-heat the feed water to the boiler temperature by means of the fuel, since this heat is added at temperatures below the maximum.

It is clear that this defect could be overcome if the heating of the feed could be accomplished by transfer of heat from the steam at corresponding stages of equal temperatures, or in other words, by a regenerative process. With the addition of such a process the cycle would be thermodynamically reversible, and under such conditions the efficiency of the Rankine cycle for saturated steam would be brought up to that of the Carnot cycle. In practice, a close approximation to this regenerative process can be obtained by the employment of a sufficient number of feed-water heaters in cascade, supplied with steam tapped off from suitable stages of the turbine.* The steam which thus transfers its heat to the feed heater is, first of all, made to do some work by expansion in the turbine down to the temperature at which it is required for withdrawal to the corresponding heaters, and since a certain amount of heat is required for the feed in any case, the work obtained from this tapped-off steam is obtained merely at the expense of additional heat equal to the work done by it; in other words, this additional heat is utilised at nearly 100 per cent. efficiency. Expressed in another way, the utilisation of some of the heat of the steam to preheat the feed water reduces the amount of heat that is required from the fuel and also that rejected to the condenser.

A large number of such stages of feed heating introduces some complications in the pipe work involved, but even with two or three stages very considerable heat economy can be effected. Generally speaking, economisers are used for the final heating of the feed water, but there is a tendency to develop the cascade system further, so as to carry the steam heating of the feed water up to the highest possible temperature, the economiser being thus displaced and the residual heat of the flue gases from the boiler plant being utilised for regenerative preheating of the incoming air to the furnace.

With highly developed regenerative feed heating, the theoretical efficiency of the Rankine cycle for saturated steam can thus be brought approximately up to that of the ideal Carnot cycle, viz., $\frac{T_1 - T_2}{T_1}$, which is the maximum thermodynamically possible between the temperature limits T_1 and T_2. Further increase of efficiency can only be sought in an extension of these limits.

Progress in the manufacture of materials capable of withstanding high temperatures now permits a maximum steam temperature of about 750 deg. F. Unfortunately, increase of pressure has not as yet kept pace with increase of temperature to this value, and it is not possible to continue to employ the saturated steam cycle receiving all its heat at this higher temperature. Since, however, in a superheated steam cycle the heat that is absorbed during the process of

* Paper read at the International Mathematical Congress at Toronto, Friday, August 15, 1924.

* Feed heating in a single stage by partly expanded steam was proposed by James Weir in 1876 and by Normand in 1889; and feed heating in progressive stages was proposed by Ferranti in 1906.

evaporation, viz., the latent heat of the steam, is a large proportion of the total heat transmitted to the boiler, some improvement in efficiency is obtained by increasing the boiler pressure, which, by increasing the temperature of evaporation, increases the mean temperature of heat reception of the whole cycle. Thus, if we assume that by the use of feed heaters in cascade, as just mentioned, the water is fed into the boiler at the boiling temperature, with a boiler pressure of 250 lb. per square inch, and a maximum temperature of 750 deg. F. after superheating, the mean temperature of heat reception is about 430 deg. F. If, however, the boiler pressure is increased to, say, 2,000 lb. per square inch, with the same upper limit of temperature as before, owing to the fact that the latent heat is now received at a higher evaporation temperature, the mean temperature of reception is considerably increased, viz., to 680 deg. F.

When adopting a high boiler pressure such as that just mentioned, it is advisable to have a small auxiliary high-pressure turbine with several stages of small diameter running at high revolutions and exhausting into the turbines at what is now ordinary boiler pressure. Such high-pressure turbines are actually being built, one in Great Britain for 1,500 lb. per square inch and one in the United States for 1,250 lb. per square inch.

Even with such pressures, a maximum temperature of 750 deg. F. still allows further heat to be added, thereby superheating the steam, and it is not therefore possible in this cycle quite to realise the full efficiency corresponding to a maximum temperature of 750 deg. But a further improvement would result if, after superheat to the maximum temperature, further heat was added so as to maintain isothermal expansion at this maximum temperature throughout the initial stages of the turbine, carrying it to such a point that subsequent adiabatic expansion in the turbine to the condenser pressure would leave the steam just saturated at that pressure. Such isothermal expansion of gaseous steam is hardly practicable in a separated engine, but, as a practical approximation to it, there is adopted in some installations at the present time reheating of the steam, which, after a certain amount of expansion in the turbine is extracted and raised again to a high temperature in a reheater and led back to the turbine to continue its expansion. Such additional heat is added at a temperature higher than that which would otherwise have been the mean temperature of heat reception for the working fluid.

Reheating has the additional and important advantage of keeping the steam longer in a superheated condition, and therefore diminishing the range where moisture, and consequent loss by water resistance, occurs.

With regard to the lower temperature limit, it is evident that any reduction of the final temperature T_2 will increase the value of $\frac{T_1 - T_2}{T_1}$ for the theoretical maximum efficiency. This, for a steam engine, means a higher condenser vacuum, and the utilisation of high vacuum becomes a most important factor in the design of the turbine, since it involves the necessity of providing ample blade area and passage way for the great volume of low-pressure steam. The volumetric expansion of the steam in its passage through a turbine is provided for partly by increase in the area of the blade passages and partly by increase in velocity. With the high peripheral speeds adopted in most low-pressure blading at the present time, while the steam speed may be such as to give a perfectly satisfactory velocity ratio it may entail a loss of kinetic energy of considerable amount in the steam leaving the terminal blades.

A simple solution for the exhaust area problem in large machines is to provide a separate low-speed turbine of large diameter for the final stages of the expansion arranged in close proximity to the condenser.

Application of all the foregoing principles is being made in a turbine plant of 50,000 kw. capacity which has been built at Newcastle-on-Tyne for the new Crawford Avenue Power Station, Chicago. This plant has been described and illustrated in the contemporary press, to which I may refer those desirous of studying the technical details. It is perhaps interesting to add that the thermal efficiency, from fuel to electricity, is anticipated as being about equal to that of the best internal-combustion engine.

The annexed table shows the estimated consumption of fuel oil per brake horse-power burnt under the boilers working at various pressures up to 2,000 lb. per square inch.

TABLE SHOWING THE OVERALL THERMAL EFFICIENCIES WHICH IT IS ESTIMATED COULD BE REALISED WITH INCREASED BOILER PRESSURES UP TO 2,000 LBS. PER SQ. IN.

(Based on the Callendar tables and formulæ for the properties of Steam.)

Column No.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Case No.	S.V.P. Lb. Gauge.	S.V.T. deg. F.	Deg. F. Initial Superheat.	Assumed Reheat Pressure, lb. abs.	Reheat Temp., deg. F.	Restored Superheat, deg. F.	Exhaust Vacuum In. Hg. Bar. 30 in.	Stage Feed-Water Heating from 65 deg. F. up to (deg. F.)	Thermal Efficiency (from Steam to Electricity).	Assumed Boiler Plant Efficiency (including all aux.).	Overall Thermal Efficiency (from Fuel to Electricity.)	Per cent. Reduction in Fuel Consumption.	Equivalent Lb. Oil B.h.p.-hr.
		Deg.	Deg.		Deg.	Deg.	In.	Deg.					
I ..	250	750	344	65	700	402·0	29·25	360	31·6	84·0	26·52	—	0·501
II ..	500	750	281	100	700	372·0	29·25	420	33·5	83·5	27·97	5·45	0·475
III ..	1,000	750	204	150	700	343·0	29·25	510	35·2	83·0	29·20	10·08	0·455
IV ..	1,500	750	153	250	700	299·0	29·25	550	36·6	82·5	30·20	13·82	0·440
V ..	2,000	750	114	400	700	254·5	29·25	600	37·5	82·0	30·75	15·90	0·432

NOTES:—
S.V.P. = stop-valve pressure.
S.V.T. = stop-valve temperature.
Feed water heated to within about 50 deg. F. of boiler temperature by means of steam withdrawn from turbine blading at several points.
Boilers equipped with economisers, or air pre-heaters, or both, so as to recover heat from the flue gases and maintain high thermal efficiency.
Dynamo efficiency taken as 96·5 per cent. at full rated output.
Gross calorific value of fuel oil taken as 18,500 B.Th.U. per lb.

In such an arrangement it is desirable, in order to obtain good efficiency in the high-pressure range, to adopt a separate fast-running high-pressure turbine. The three turbine arrangement, consisting of high-pressure, intermediate and low-pressure turbines geared to the propeller shaft, is specially applicable under such conditions. Assuming such a design to be adopted for an installation of about 5,000 shaft horse-power, with boiler pressure 500 lb., temperature 700 deg. F., feed heating to 350 deg. F., and effective air preheating to give a boiler efficiency of about 84 per cent., a careful estimate based on known performance shows that, owing to the increased available energy of the steam, a fuel consumption of about 0·57 lb. of oil per shaft horse-power hour would be obtained for turbines only, and 0·69 lb. per shaft horse-power hour, including auxiliary machinery.

When the difference in price between fuel oil and Diesel oil is taken into consideration, these being in about the ratio of 3 to 4, and allowance is also made for the cost of lubricating oil for the Diesel engine in excess of that for the turbine, it will be seen that these figures are equivalent to about 0·38 lb. of Diesel oil per shaft horse-power hour for turbines only, and 0·475 lb. Diesel oil per shaft horse-power hour for all purposes, including auxiliary machinery, and, therefore, promise an economy of fuel superior to that obtained with Diesel engines; whilst the first cost of such an installation will be little if any greater than that of a geared-turbine installation of the usual design with low pressures and moderate superheat, and considerably less than the cost of an oil engine.

It will thus be seen that, by practical application of the principles discussed above to the expansion of steam in a turbine, overall thermal efficiencies can be realised which are not inferior to those of internal-combustion engines.

It has been further suggested to employ a binary vapour process, utilising another fluid with a lower vapour pressure, such as mercury for the higher range of temperature. This would enable the whole of the heat to be received at the maximum temperature without employment of high pressures and theoretically a slight gain would result. Within the limits of temperature, however, which present-day materials make practicable, it would appear doubtful whether the losses incurred through the double transmission of heat in such a process would not outweigh the theoretical gain, and, moreover, there are obvious objections to the use of such a fluid as mercury.

Applying the same principles to marine work, it is interesting to enquire what results can be obtained by using high temperature and boiler pressure, stage feed heating and air preheating, but without intermediate reheat.*

* The adoption of reheat after partial expansion would involve carrying a steam pipe of large capacity twice through the bulkhead separating the engine room from the boiler room, and this, though not impossible, is open to objection.

CATALOGUES.

Oil Engines.—A catalogue illustrating and describing the Fullagar opposed-piston oil engine, as constructed by the English Electric Co., Limited, Queen's House, Kingsway, London, W.C., is to hand from that firm.

Cast-Iron Pipes.—A list of cast-iron pipes in stock for immediate despatch, giving particulars of diameter, length, end connections and quantity available, is to hand from the Staveley Coal and Iron Company, Limited, Chesterfield.

Switchgear.—Four leaflet catalogues dealing with ironclad switch pillar units for mining and industrial use, sheet-steel cubicles and switchboards, oil-immersed switch-fuses, and isolating links are to hand from the New Switchgear Construction Co., Limited, Sutton, Surrey.

Refrigerating Machinery.—Messrs. Sulzer Brothers have sent us from their London Office, 31, Bedford-square, W.C., a handsomely printed catalogue of refrigerating plant, including complete installations for cold stores, breweries, chemical works, &c., which are well illustrated and clearly described.

Wire-Working Machines.—The Orb Engineering Works, Limited, Middleton Junction, Manchester, have sent us a catalogue of their automatic machines for continuously drawing and cutting off wire to accurate lengths. The machines are made in three sizes, dealing with wire from 17 S.W.G. to ¼-in. rods.

Gas in the Textile Industries.—An eight-page pamphlet issued by the British Commercial Gas Association, 30, Grosvenor-gardens, London, S.W. 1, contains articles on the uses of gas in the textile industries, the special operations dealt with being stentering, wool conditioning, cloth shrinking and artificial silk drying.

Switchboards.—The General Electric Co., Limited, Magnet House, Kingsway, London, W.C., have sent us two catalogues dealing with switchgear, one relating to unit type switchboards and the other to ironclad switchboards for direct or alternating current circuits up to 660 volts, for two or three-wire distribution.

Investigation of Machinery Noises.—An account of the many applications of the stethoscope for investigating or recording the internal noises of mechanisms or the vibration of structures is given by Mr. C. E. Noel-Storr in a little 16-pp. pamphlet issued by the Capac Company, Limited, 24, Bruton-place, New Bond-street, London, W.

Transformers.—The British Electric Transformer Co. Limited, Hayes, Middlesex, have issued a catalogue of Berry transformers of the radial and core types. The core type has been made specially for three-phase work, and units with capacities up to 5,000 kv.-a. and for pressures up to 90,000 volts are now in operation.

Drawing Instruments.—Messrs. B. J. Hall and Co., Limited, Great Peter-street, London, S.W. 1, have sent us a catalogue showing a very considerable variety of drawing instruments, supplied in complete sets, half sets or singly, and also giving particulars of planimeters, integrators, integraphs, pantographs, and eidographs.

Boiler Furnaces.—A little booklet giving particulars of their furnaces for boilers and for refuse destructors, and containing much useful information on the subject of economical fuel consumption, has come to hand from Messrs. Meldrums, Limited, Timperley, near Manchester. An oil burner and a special fire bar for dust fuels are also described.

Belt Conveyors.—A carefully-prepared catalogue of belt conveyors, received from the Brown Hoisting Machinery Company, Cleveland, O., U.S.A., illustrates the application of these appliances to simple and intricate work and gives much technical information which will be useful to engineers in connection with the installation of such plant.

Switchgear and Accessories.—We have received a number of catalogues from the British Thomson-Houston Co., Limited, Rugby, all of which have been carefully prepared with useful explanatory matter, illustrations and technical and commercial information. They well maintain the high standard of this company's trade publications. The catalogues deal with field rheostats with capacities up to 60 amperes at 600 volts, pulleys up to 36 in. in diameter and 12 in. wide for generators and motors, air-break knife switches, iron-clad truck switchgear for three-phase systems up to 11,000 volts, and oil-immersed circuit breakers of the spring-operated, motor-controlled type.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

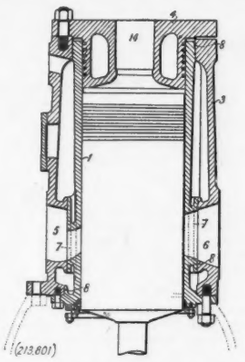
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

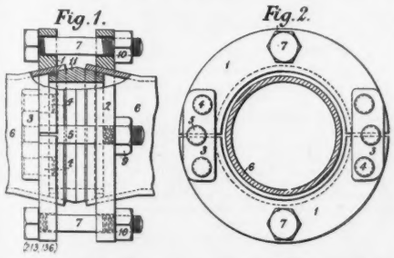
213,801. Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, and J. S. Simm, Monkseaton. Internal-Combustion Engine Cylinders. (3 *Figs.*) May 28, 1923.—The invention relates to cylinders for single-acting two-stroke internal-combustion engines of the type comprising a jacket fitted with a ported liner forming the working barrel, the liner being adapted to receive a cover secured to the jacket. According to the invention, the flange of the liner is exterior to the jacket; fluid-tight joints are provided between the liner and the jacket in the neighbourhood of the ports; and the cover is provided with a central aperture to receive the valves. 1 is the liner, which is adapted for insertion in place from the crosshead end of the cylinder and is provided with a flange which is secured to the cylinder jacket 3 at the crosshead end,



the flange being exterior to the jacket. The lower part of the liner 1 is ribbed or thickened at the locations of the scavenge and exhaust ports 5, 6. Cooling-fluid channels 7 traverse the bars between the ports. At the breech end of the cylinder, the liner 1 is extended for reception of the cylinder cover 4. Fluid-tight joints are provided between the liner 1 and the jacket 3 at the scavenge and exhaust ports 5, 6, and also near the uppermost and lowermost ends of the liner 1, to prevent leakage from the jacket space, such joints being preferably effected by rings 8 of copper or rubber set in grooves in the liner 1 so as in no wise to impede convenient removal of the liner. The cover 4 is provided with a single central aperture 14 to receive a cage carrying the fuel-injection valve, the starting-air valve and such other valves as may be required. (*Sealed.*)

HYDRAULIC MACHINERY.

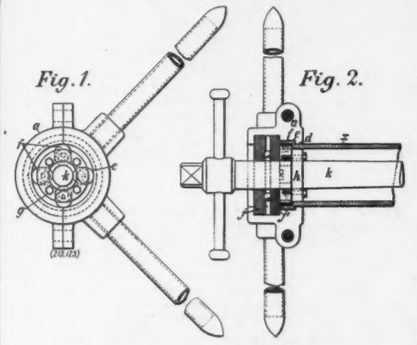
213,136. C. Williams, Brynmill, Swansea, W. G. Bellamy, Morriston, and the British Mannesmann Tube Company, Limited, Landore, Swansea. Loose-Flange Pipe Joints. (9 *Figs.*) April 19, 1923.—The invention relates to loose-flange pipe joints of the kind wherein one or more split flanges and connections are used in conjunction with a number of flange coupling bolts and nuts. According to the invention, the two halves of a split flange situated on one side of a pipe joint are connected together by means of a pair of plates arranged on either side of the pipe and secured to the split flange members by means of pegs or pins, which are fixed to, or engaged with, the plates and extend into holes in the split-flange members, or *vice versa*, and the two halves of the split flange are secured to the



solid or split felloe, or opposing flange, on the other side of the pipe joint by means of the usual flange coupling bolts, and of additional bolts connected to, or engaged with the plates and extending through holes therefor in the said felloe flange. The two pipe end portions are denoted by the numeral 6, and the two split flange halves by 1, a joining or union sleeve being indicated at 11. The two halves of a split flange 1 are connected together by means of the two locking plates 3, arranged one on each side of the axis of the pipes, each plate being provided with two pegs or pins 4 arranged to enter two corresponding holes specially drilled in the flange 1 to suit. The plates are each also provided with a bolt 5 that is fixed to the plate, the bolt being screw-threaded for co-operation with a nut 9. Each bolt is of a length sufficient to enable it to pass through the two flanges 1 and 2, one on either side of the joint, and thus to draw them tightly together, in conjunction with the usual flange bolts 7 and nuts 10. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

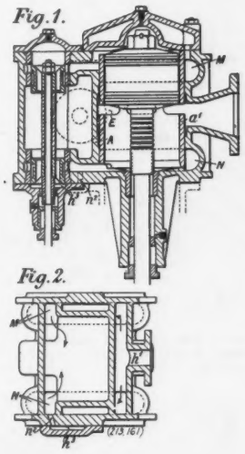
213,123. J. A. Metcalf, Wallsend-on-Tyne, and A. Lennox, Wallsend-on-Tyne. Tube-Expanding Tools. (2 *Figs.*) April 3, 1923.—The invention relates to tube-expanding tools of the kind wherein the expansion is performed by means of rollers contained in a cage and forced outwards by a tapered spindle, which is rotated and moved axially. *a* is a housing which is provided at its inner end with an aperture *d* through which the end of the tube *x* to be expanded is introduced into the housing. Adjoining the aperture is an annular recess *e* of a diameter not less than the desired external diameter of the end of the tube when expanded, so that it may form a matrix. *f* are the rollers disposed in a cage *g* closed by a detachable cover-plate *h*. The



cage is fixed to, or integral with, one race ring j^1 of a thrust bearing *j* fitted inside the housing. *k* is a tapered spindle which extends axially through the housing and members *j*, *g* and *h*, the rollers *f* bearing on the periphery of the spindle and being forced outwards and rotated when the spindle is rotated and moved axially. For expansion, the end of the tube is introduced into the housing through the aperture *d*, the face of the ring j^1 forming an abutment for the end of the tube and correctly locating the latter with the aid of the member *h*. The spindle *k* is then rotated and is forced axially inwards, so that the rollers expand the end of the tube into the annular recess *e*, thereby producing a collar on the end of the tube. (*Sealed.*)

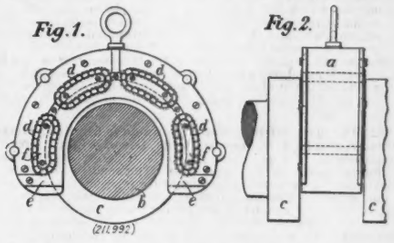
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

213,161. H. B. Watson, Newcastle-on-Tyne, and T. C. Billetop, Newcastle-on-Tyne. Steam Engines. (8 *Figs.*) December 1, 1922.—The invention relates to steam engine of the uniflow type with central-belt exhaust ports. According to the invention, the steam jackets of uniflow steam engines are constructed by providing in the interior of the cylinder casing A annular recesses M, N parallel with, and near to, the central-exhaust belt E, the edges of the recesses forming part of the bore of the cylinder casing and making joint with the exterior surface of the



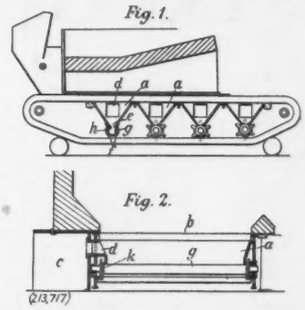
cylinder liner a^1, when the latter is introduced, so that the liner forms the inner wall of the jacket. The actuating steam enters by the inlet h^1 and passes in the direction of the arrows to the valve casing with which both belts communicate, the arrangement being such as to ensure the steam passing through both jackets round the cylinder liner before it enters the valve casing. Any condensation water in the jacket M passes to the valve casing with the steam, and condensation water formed in the jacket N passes through the port n^2 and thence through the chamber h^3. (*Sealed.*)

211,992. W. Whelan, Stoke, Devonport. Thrust Bearings for Marine Engines. (4 *Figs.*) December 9, 1922.—The invention relates to ball-thrust bearings of the type in which the balls are disposed in races, which have the form of closed curves that do not encircle the shaft, are retained therein by slotted plates, and come into or out of rolling contact with members having plane thrust surfaces lying transversely of the shaft. According to the invention, the shaft is provided with thrust collars of the kind usual in marine thrust bearings, and the ball-races are carried by members which surround the shaft, except for a space to permit of their removal, and have faces which are adjacent to those of the thrust collars and in which the races are located. The body of the thrust block *a* is made in horse-shoe form and partly surrounds the shaft *b*. The shaft carries two collars *c*, *c*, one of which takes the ahead thrust and one the astern thrust. In each face of the thrust block, there are four curved races *d*, each filled with steel balls. The balls are kept in place by two cover plates *e*, *e*, which cover the faces of the thrust blocks, and the small centre plates *f*, between which and the cover-plate spaces are left, through which the balls are free to project



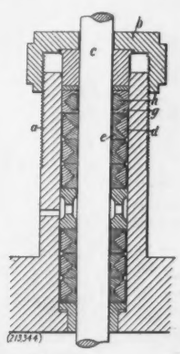
slightly beyond the face of the cover-plate. The collars *c*, *c* have the diameter shown, the balls beyond this being free of the collars, consequently, the balls, in passing round the races, pass into and out of action. (*Sealed.*)

213,717. The London Electric Supply Corporation, Limited, London, and A. G. Fox, New Cross, London. Furnaces. (6 *Figs.*) January 27, 1923.—The invention relates to furnaces for steam generators fitted with chain or travelling grates. The invention consists in providing a number of parallel, substantially V-shaped, ducts *a* running transversely across the under surface of the grate, these ducts being supplied with air under pressure from one or more ducts *c* which run longitudinally of the grate and communicate through apertures *d* with the transverse ducts *a*. These transverse ducts are provided with openings for discharging riddlings, and to these openings are fitted rotatable or movable sealing devices, so that when they are operated the riddlings are passed out of the duct without opening the seal, thus preventing the air under pressure from escaping



through the opening. The sealing device illustrated comprises two arch shaped guides *f* secured to the sides of the duct *a* and forming a seat for a substantially cylindrical hollow drum *g* having a slot *h* extending along it. The drum is provided with ends having gudgeon pins on which are mounted sprocket wheels *k*, the teeth of which mesh with the links of the underside of the grate *b* as it is returning to the front end, so that movement of the grate causes rotation of the wheels and the drum. When the slot *h* in the drum registers with the slot *e* in the bottom of the chamber *a*, the riddlings which have accumulated in the chamber drop into the interior of the drum. When the drum has been rotated through approximately 180 deg., the slot *h* registers with the space between the guides *f*, and the riddlings are discharged from the drum. (*Sealed.*)

213,344. Sir A. S. Haslam, Derby. Packing. (1 *Fig.*) January 1, 1923.—The invention relates to packings of the known type consisting of a series of metallic rings of combined hard metal and plastic metal. According to the invention, the packing consists of a series of steel carrier rings *d* of a pentagonal, triangular or any other suitable section. The outside diameter of the steel ring is preferably smaller than the inside diameter of the stuffing box *a*, so that the rings are not in contact with the sides of the stuffing box; any friction on the sides of the stuffing box is thus avoided and pressure is transmitted equally along the



whole length of the packing in the stuffing box. If preferred, the outside diameter of the steel rings may be made the same as the inside diameter of the stuffing box. On the inner side of each of these rings there is mounted a soft plastic metal ring *e* in such a manner that the top and bottom surfaces of the soft metal extend beyond the surfaces of the hard metal. This ring is preferably concave in section and is cast on a triangular steel ring *d* having two inner angular faces which enter into the concavity, a ring of approximately rectangular section of hard and plastic metal being thus formed. The inner side of the soft metal surface is in contact with the piston rod and may

be provided with a series of circumferential oil grooves. When arranged on a piston rod *e*, any two rings are placed side by side and the soft metal is retained between the two hard metal angular rings. As the rings are pressed together the soft metal becomes interfluent between the two hard angular surfaces, forcing the soft metal inwards on to the piston rod. On the outer end of the gland box is a screwed cap *b* which forces the packing inwards, and the piston rod is lubricated by the interposition of a tube or lantern gland drilled to admit the oil. It is preferred that, on the outer side of the last steel carrier ring *h*, a soft plastic metal ring *g* be mounted, which is in contact with the inner side of the stuffing box in order to retain the oil in the stuffing box, the inner side being clear of the piston rod to avoid friction. (*Sealed.*)

212,815. The Stirling Boiler Company, Limited, Westminster, and H. J. S. Mackay, Ryde, Isle of Wight. Steam Generators. (2 *Figs.*) July 10, 1923.—The invention relates to improvements in five-drum vertical or semi-vertical water-tube boilers, of the curved or straight tube type, having two lower or mud drums. In accordance with the invention, the lower halves only of the lower or mud drums are connected by curved tubes, preferably uniformly spaced lengthwise of the drums and all connected with the drums in proximity to the lowest level, the tubes being of such curvature that a portion of every tube lies below the bottoms of the drums. As shown, and in accordance

Fig. 1.

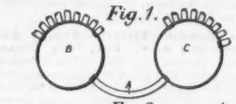
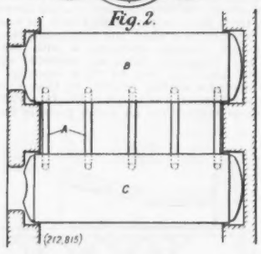


Fig. 2.



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with the present invention, the mud-drum-connecting-tubes A are arranged to connect only the lower halves of the lower or mud drums B and C, being connected with the drums B and C in proximity to the lowest level thereof and of such curvature that the middle portion of every tube lies below the bottoms of the drums. It will be understood that by virtue of the arrangement of the tubes. A connecting the lower portions of the two mud drums, a greater movement than hitherto usual of the water in these regions is afforded, permitting of better circulation and equalisation of the temperatures with consequent reduction in the stresses on the riveted joints on the drums. (*Sealed.*)

212,967. The Mirrlees Watson Company, Limited, Glasgow, and W. A. Dexter, Glasgow. Surface Condenser Installation. (2 *Figs.*) December 16, 1922.—The invention relates to surface condenser installations of the type in which provision is made for maintaining a constant load on the condensate pump. Installations of this type usually include a collecting box or chamber located below the main condenser for the reception of condensate from the condenser and a centrifugal condensate pump connected on its suction side to the collecting box and on its discharge side by a dis-

Fig. 2.

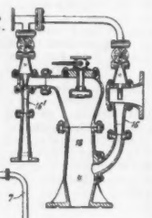
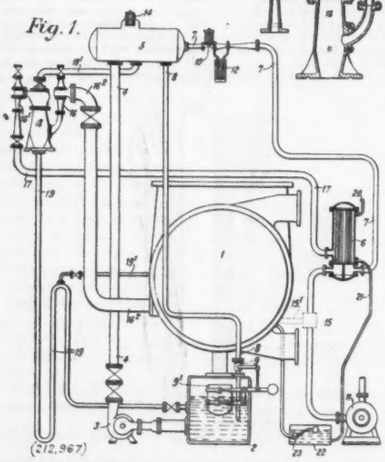


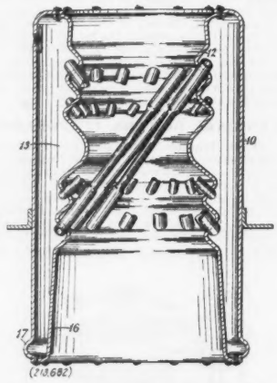
Fig. 1.



(212,967)

charge pipe to a so-called overhead tank, such overhead tank being connected directly to the feed heater, and, by an equalising pipe, to the collecting box. According to the invention, the so-called overhead tank is formed as a sealed chamber from which a connection is taken directly to the feed heater and through the heater to the feed pump or feed tank, so that the condensate pump serves to create an artificial head, and that the feed heater and the feed pump, or the feed tank, may be situated conveniently without the necessity for providing a substantially static head. 1 denotes the main condenser below which is located a collecting chamber 2 connected to the main condenser and serving for the reception of condensate from the condenser. The centrifugal condensate pump 3, is connected, on its suction side, to the collecting chamber 2 and on its discharge side by a discharge pipe 4 to an overhead tank 5. The tank 5 is connected to the feed heater 6 by piping 7 and to the collecting chamber 2 by an equalising pipe 8, the flow of water from the tank 5 to the chamber 2 being automatically regulated by a valve 9 controlled by a float 9¹. The tank 5 is formed as a sealed chamber, the connection from which to the feed heater 6 is controlled by a manually-regulatable spring-loaded valve 10, the said connection extending through the feed heater 6 to the feed pump 11. 12 denotes a Venturi-meter which serves to measure the total quantity of condensate passing through the piping 7 to the feedheater 6. To ascertain the quantity of steam condensed in the condenser, there is subtracted from the quantity measured by the meter the calculated quantity of steam used in operating both stages 16, 16¹ of the ejector air pump of usual construction, the primary stage 16 of which is connected by a valved pipe 16² with the condenser 1. Steam from the primary stage 16 condensed in the jet condenser 18 connected with the tank 5 by the valved pipe 18¹ passes with the injection water by way of the connection 19 to the collector chamber 2 and into the closed circulation system, the connection 19 having a return bend with a valved branch or air passage 19¹ leading to the condenser 1. Steam from the second stage 16¹ passes with the air by way of the pipe 17 to the feed heater 6 which also functions as a surface condenser, having a vent 20 and a drain connection 21 leading to a tank 22 fitted with a float-controlled valve 23 regulating the flow from the tank 22 to the condenser 1. The tank 5 has an air vent controlled by a valve 14 permitting discharge of air from the closed system. 15 denotes a normally closed thermostatic valve for by-passing overheated water from the feed heater 6 to the condenser 1 by way of the connection 15¹. (*Sealed.*)

213,682. S. E. Alley, Westminster, London, and A. C. Hutt, Shrewsbury, Shropshire. Vertical Steam Boilers. (1 *Fig.*) January 6, 1923.—The invention relates to vertical steam boilers of the type having a central combustion chamber over the fire grate and surrounded by an annular water space which is enclosed between the combustion chamber and the boiler shell. According to the invention, a vertical steam boiler comprises a central combustion chamber 12 having a fire grate, an outer shell 10 that surrounds the combustion chamber and forms with it an annular water space 13 of relatively large area at the working water level and of smaller area at other levels therebelow. The shell 10 is circumferentially bulged outwards at 17 near its lower end at and near the level of the fire grate, as compared with its size at other levels, the vertical section of the bulge 17 exhibiting reverse curves and the combustion chamber



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having a downwardly and outwardly flaring lower conical portion 16 at and above the situation of the bulge 17. In this way, an increased grate area is obtainable without increasing the diameter of the shell except locally at the situation of the bulge 17, and an increased size of combustion space is provided. Moreover, the annular water space 13 is reduced in volume and consequently the weight of water carried is reduced; also a conveniently large annular space is provided at the situation of the bulge 17 to permit of the collection of the scale and deposit usually to be expected at the bottom of a boiler. There is the further important advantage that the form of bulge employed makes the boiler less rigid along the length of its axis than the usual form of such boilers with flanged ends, and the flexibility thus provided is, of course, desirable in that it reduces the trouble due to differences in expansion between the shell and the walls of the combustion-chamber. (*Sealed.*)

213,830. The Stirling Boiler Company, Limited, Westminster, London, and E. E. Noble, Fulwell, Sunderland. Water-tube Boilers. (5 *Figs.*) August 1, 1923.—The invention

Fig. 1.

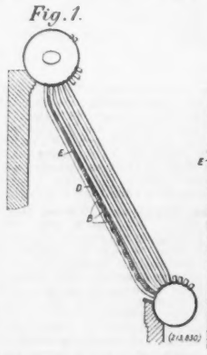
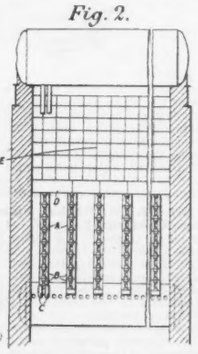


Fig. 2.



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relates to water-tube boilers of the vertical or semi-vertical type having curved or straight tubes. An object of the invention is to provide an improved baffle for use in any bank of tubes of such boilers, while a further object is to provide an arrangement of such baffles whereby the usual deflecting arch, ordinarily required in boilers using chain grate stokers, may be dispensed with. The improved baffle is built up of a series of spaced columns A, each composed of superimposed tiles or bricks B adapted to fit snugly between adjacent tubes C of a row, such columns being surmounted by bridging tiles or bricks D, which, in turn, serve to support a wall E formed of bricks or tiles and constituting the main portion of the baffle. A baffle so constructed may be erected behind the front or the second row of the first bank of tubes of a boiler of the type referred to, and will serve, in furnaces employing chain-grate stokers, as a radiant heating surface permitting of dispensing with the usual deflecting arches employed with such stokers. (*Sealed.*)

TEXTILE MACHINERY.

213,750. John Hetherington and Sons, Limited, Ancoats, Manchester, and C. W. Cooper, Brooks Bar, Manchester. Combing Machines. (2 *Figs.*) March 13, 1923.—The invention relates to combing machines, and has for its object to provide an improved device whereby the fan of the aspirator for removing the waste may be stopped or started at will. 1 is the fan-shaft upon which is keyed a sleeve 1*a*. Upon the sleeve 1*a* is loosely mounted a chain wheel 2. Slidably mounted upon the sleeve 1*a*, but fixed as regards rotation, is a half-clutch 3,

Fig. 1.

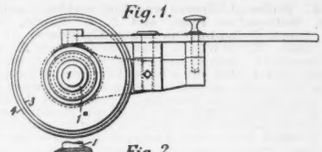
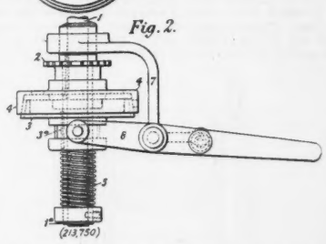


Fig. 2.



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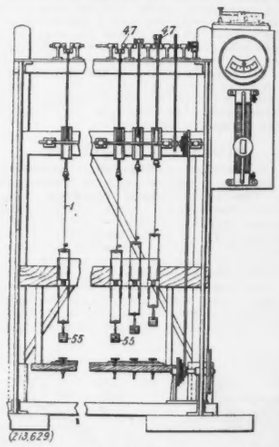
and attached to, or formed integral with, the chain wheel 2 is a second half clutch 4. The half clutch 3 is under the action of a spring 5. Loosely mounted upon the shaft 1 is a bracket 7, upon which is pivotally mounted a lever 8. One end of the lever 8 engages the groove 3*a* of the half clutch 3 and the arrangement is such that, by operating the lever 8, the half clutch 3 may be brought into or thrown out of contact with the half clutch 4, so that the fan shaft 1 may be thrown out of gear according to the requirements of the operative. (*Sealed.*)

213,629. The British Cotton Industry Research Association, Didsbury, Manchester, and A. E. Oxley, Didsbury, Manchester. Thread-Testing Machines. (11 *Figs.*) November 1, 1922.—The invention relates to a machine for testing threads. According to the invention, a thread 1 is suspended vertically in the machine and is subjected to a cyclical variation of tensional stress applied axially to it. Further, by this invention, means are provided to prevent the rotation of the thread about its axis to cause untwisting of the same. In one form of con-



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struction of the machine, the threads 1 are connected to cranks 47 at one end and carry loading weights 55 at the other, the load being such that maximum loading on the thread, which occurs with the crank at one extreme position relatively to the thread, will always be less than the breaking load of the thread. The numbers of variations of stress applied in this manner previous to the rupture of the thread is a measure of the strength of the thread when submitted to cyclical variations of stress. (*Sealed.*)

LONDON BRIDGE.—The results of the recent thorough observations on the state of London Bridge have been embodied in a report submitted by the Engineers to the Bridge House Estates Committee of the Corporation of London. The report states that the bridge is in good condition and no cause exists for the recent apprehension. Considerable attention has been given to a study of the cracks in the spandrels which have been found to vary with the temperature, and no unusual feature has asserted itself. The river bed has also been closely examined. The bridge is supported on timber foundations, thoroughly protected by silt. No movements of any kind have been discovered in the course of the investigations.